20 MAY 1965
MADRAS
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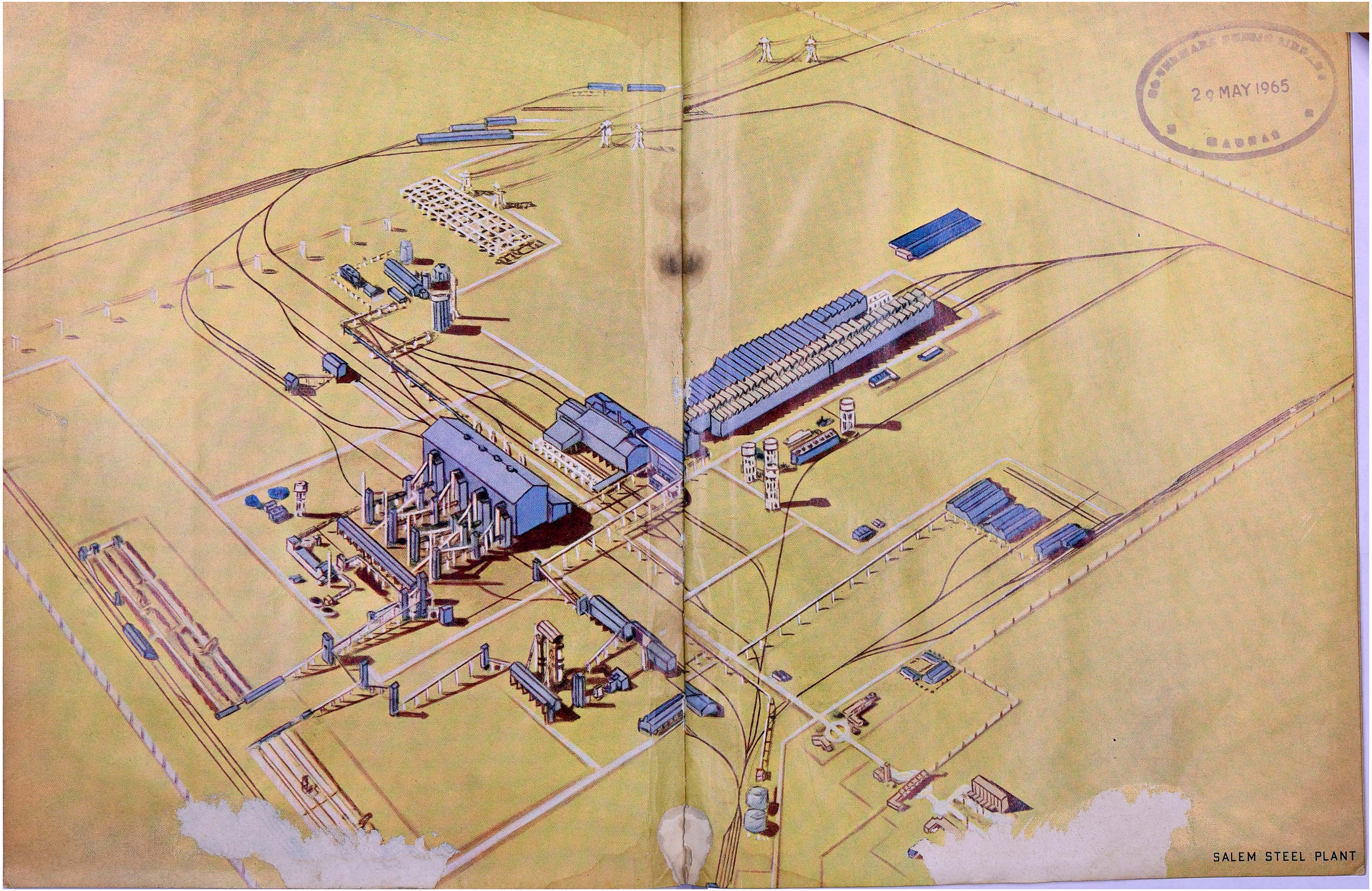
CONSULTING ENGINEERS' REPORT

ON

NEYVELI-SALEM STEEL PROJECT

—A Summary

GOVERNMENT OF MADRAS



29 MAY 1965
MADRAS

SALEM STEEL PLANT

30 MAY 1965

FOREWORD

IRON and Steel are rightly considered among the indispensable bases of economic growth of any nation. There has always been a close correlation between economic development and steel output. In the two decades following 1938, the industrial production of the world is said to have increased by 130% and its output of crude steel by 157%. The widespread beneficial effect of steel development could be gauged from the fact that every job in the steel industry creates 8 to 10 new jobs in other manufacturing industries for which the starting material is steel. Besides these factory jobs, additional employment is generated in various other fields such as mining, transport and construction. Steel production has truly been considered the barometer of economic activity. In our country, however, concerted effort to raise steel production has been made only after the attainment of Independence. As against the total production of 1·13 million tons of finished product prior to Independence, the production in 1962 rose to 3·6 million tons. The pace of steel production would have to be further accelerated to satisfy the twin demands of defence and development. Forecasts of steel demand in the country are placed at 8 million tons in 1965, 14 million tons in 1970-71 and 21 million tons in 1975-76.

2. There have been several attempts to manufacture iron in India on modern methods from as early as in 1830. The pioneering efforts of Mr. Josiah Marshall Heath, a Member of the Civil Service in our State, to establish an iron works at Porto Novo in South Arcot district were followed by efforts to start iron works in Pulampatti in Salem district and Tiruvannamalai in North Arcot district. All these gallant

efforts could not, however, gather momentum as they were faced with a host of difficulties such as financial limitation, lack of technical personnel, unfavourable climate, increasing cargo freight, non-availability of forest fuel for smelting etc.

3. The most formidable difficulty in the establishment of a modern iron and steelworks in this part of the country lay in the non-availability of coking coal for making iron in the conventional blast furnace process. As the brochure rightly emphasizes, the discovery of extensive reserves of lignite estimated at about 2,000 million tons in Neyveli gave encouragement and confidence that the dispersal of steel plants was more than a distinct possibility. The recent technological innovations in steel making the world over have also provided ways and means of utilising non-coking coals like lignite for iron and steel making. Both the iron ores of Salem with 36% of iron and Neyveli lignite with a lower calorific value than coal are unconventional raw materials. The utilisation of these raw materials involved the adoption of relatively new techniques such as magnetic concentration, pelletising, electric smelting with prereduction, LD gas recovery, vacuum degassing and continuous casting etc. which have been recommended for the Salem plant. To assess the suitability of the new techniques for utilising the Neyveli - Salem raw materials, several extensive and time consuming tests had to be undertaken in India and in various countries abroad. The criticism that is sometimes made that there has been undue delay in the utilisation of the Neyveli - Salem raw materials overlooks this important aspect of the unconventional nature of the principal raw materials. There is also some confusion regarding the quality of Salem magnetite quartzite. It is sometimes characterised as 'inferior ore'; it is also referred to by some as a 'reject'. True, the iron content in Salem ore which is about 36% is low compared to the 60 to 65% of iron in haematite ores in the country. But metallurgists are of the view that when the value of an iron ore is assessed, it is not merely the iron content which has to be considered but also the extent to which the injurious substances like phosphorus, sulphur etc. are

present in the ore. Sulphur in the ore is detrimental because it makes iron brittle at red heat. The phosphorus in the iron ore tends to be absorbed in the iron when smelted and phosphoric pig iron cannot be used for several steel making processes. The Salem iron ore, although having a comparatively low percentage of iron content, has the distinctive advantages of low phosphorus and low sulphur. I may add here that I have seen several iron and steelworks in the West utilising ore with percentage of iron content of the order of the Salem ore.

4. An indication of the various tests done on the Neyveli-Salem raw materials would enable a clearer appreciation of the extent to which the Project has been shaped. Encouraging news came of the production of iron by utilising high temperature carbonised lignite briquette coke as reducing material in the German Democratic Republic. In that country, the shortage of coking coal has compelled them to turn to lignite coke as a reducing agent for iron ore in the low shaft furnace. Briquettes carbonised at a temperature of 1000°C at the Lauchhammer plant are transported to Calbe (about 180 kilometres away) and utilised for the reduction of low grade iron ore in a factory in which a number of low shaft furnaces are functioning. I had occasion to visit the Calbe factory in the latter part of 1961 and I was shown how iron ore with only 20 to 25% iron content was being utilised successfully to produce iron. The gas coal coke from Zwickau was also used along with the high temperature lignite coke as a reductant. As the successful working of the Calbe Plant held immense promises for the adoption of similar techniques in our country, laboratory and pilot plant tests were arranged to be conducted in East Germany. A Team of Experts from the German Democratic Republic came to our country at our invitation in April 1960 and on their study of the Neyveli-Salem raw materials, a large quantity of about 2,000 tons of raw lignite and matching quantities of other raw materials were sent to East Germany towards the end of 1961. The tests were comprehensive and covered several aspects of iron making such as sintering and smelting of iron ore, high temperature carbonisation

of the Neyveli lignite etc. These tests demonstrated that the low shaft furnace developed in the German Democratic Republic was suitable for pig iron and steel making with the Neyveli-Salem raw materials. These tests yielded very good results and confirmed that the Salem iron ore concentrates have excellent sintering properties and that the high temperature lignite coke produced from Neyveli lignite has adequate strength. It may be noted that the low shaft furnace is similar to blast furnace operation particularly as regards the blast, cowper operation, gas purification etc., but with this difference that non-coking coal which could not be charged in the conventional blast furnace could be utilised in the low shaft furnace process.

5. Although the tests on the low shaft furnace in the German Democratic Republic were encouraging, there were, however, one or two factors requiring further attention. These related to the high coke consumption and the large slag volume noticed in the low shaft furnace trial operations.

6. Tests were therefore carried out on the then recent prereduction process utilising electric energy for smelting. The well-known Norwegian firm of Elektrokemisk, who had earlier conducted laboratory scale tests on our raw materials, was requested to conduct pilot plant tests. I had occasion to visit their pilot plant at Fiskaa Verk in 1962. In their furnace at Fiskaa Verk, Elektrokemisk had carried out tests for various countries such as Portugal, Egypt, Japan, Yugoslavia, New Zealand for utilising unconventional raw materials such as low grade iron ore and non-coking coals (Elkem process). During my visit to their plant, I was informed that they had designed three furnaces together with rotary kilns for the Yugoslavian Steel Project at Skopje to produce pig iron, utilising low grade chamosite (iron silicate) and lignite. These tests conducted by Elektrokemisk established the feasibility of economic production of iron with Neyveli lignite and Salem iron ore based on the electric smelting technique with prereduction.

7. Among the significant features of the Elkem process is the fact that the low temperature carbonised lignite briquettes obtained from the Briquetting and Carbonisation Factory at Neyveli could be readily used in the Salem Plant. This is in contrast to the low shaft furnace process requiring high temperature carbonised lignite briquettes. The ready and easy availability of low temperature carbonised briquettes expected from the unit set up in Neyveli and with a reasonable price for power consistent with high load factor and power factor which electric smelting involves, resulted in the Elkem process unfolding the prospect of economic production of iron and steel based on the electric smelting technique with prereduction.

8. During these tests, discussions centred round the possibility of using air-dried raw lignite directly in the prerotary kiln. The conduct of tests on our raw materials in this regard by the Strategic-Udy Processes Incorporated of U. S. A. indicates the possibility of adopting their process, after it is commercially proven, by which air-dried raw lignite could be directly fed in the kilns eliminating the need for briquetting, carbonising etc.

9. More recently, bulk samples of about 7,500 tons from hundred slits and one tunnel driven in the iron ore band in the Kanjamalai hills have been collected and representative sample sent to concentration equipment suppliers abroad such as Sala Maskinfabriks of Sweden, Lurgi Chemie of West Germany, General Electric Company of United Kingdom etc. for obtaining guarantee of performance of the equipment offered by the suppliers. Committees appointed by the Government of India and the State Government have gone into these large volume of technical data. Based on these, the Government of India appointed in 1963 Messrs. M. N. Dastur & Company Private Ltd., Calcutta, as Consulting Engineers for preparing the detailed Project Report. Their Rs. 95 crore detailed Project Report envisaging the production of 0·5 million tons of steel per annum in the first stage has placed beyond doubt the production, at competitive price, of quality steel at

Neyveli-Salem steelworks. It is useful to remember that the detailed Project Report represents the pre-engineering of the Project and has comprehensively evaluated the raw material availability and suitability, the production processes and the economic viability. The stage is thus set for the sanctioning of this scheme.

10. This booklet prepared by the Department of Industries, Labour and Co-operation attempts to bring out, in a short compass, the salient features of the seven volume detailed Project Report submitted by the Consulting Engineers. It has been written primarily with an eye for the non-technical reader.

11. The State Government have, at the request of the Government of India, notified, early this year, under the Land Acquisition Act, an extent of about 24,000 acres (about 37 square miles) in Salem district representing the land requirement of the plant, township, the railway siding, marshalling yard, ancillary industries and mining. It would thus be seen that considerable headway has been made in processing the Project to a concrete shape. The Project is thus well poised for implementation for which a construction schedule of 4½ years has been drawn up by the Consultants. It is hoped that this Project would be taken up for implementation at the earliest and would constitute a significant mile-stone in the development of our economy.

FORT ST. GEORGE,
MADRAS-9.
17—10—1964

R. VENKATARAMAN,
Minister for Industries,
Government of Madras.

29 MAY 1965
MADRAS

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CHAPTER I

INTRODUCTION

1. In February 1963, the Government of India appointed Messrs Dastur & Company Private Ltd., Calcutta, Consulting Engineers, for preparing the detailed project report for establishing in the State of Madras a highly efficient and modern iron and steel works with an initial capacity of 300,000 to 500,000 tonnes of ingots per annum (capable of further expansion) converted into finished rolled steel products. The terms of reference are in Appendix I. The consultants have submitted their report in August 1964. This brochure is a brief summary of the report. The Rs. 95 crore detailed project report, which represents the pre-engineering of the Project, envisages the production of 5 lakhs tons of steel per annum, with provision for expansion to 1·2 million tons in the 2nd stage and 3 million tons later on. The comprehensive report has appraised the physical and chemical characteristics and prices of the principal raw materials such as iron ore, lignite, limestone and refractory raw materials. It has studied the regional and all-India demand for steel, the supply position from the existing sources and recommended the initial capacity and product-mix of the Plant. After evaluating the several alternative processes of iron making, the Consultants have recommended the most suitable and economical metallurgical processes. After a study of the various sites in the Neyveli-Salem region, the Kanjamalai site (14 kilo-metres west of Salem) has been recommended because of its favourable location in respect of raw materials assembly cost, availability of abundant water, proximity to power generation, as well as broad and metre gauge railway facilities which provide ready access to raw material sources and to market for finished products. The Report has conclusively established the technical feasibility and the economic viability of the Salem Steel Plant.

2. Although the availability in the Neyveli-Salem region of abundant iron ore of over 370 million tons and matching quantities of suitable limestone and magnesite etc., required for iron making, has been known for quite a few years, the proposal for a steelworks could not hitherto take a concrete shape due to the non-availability of metallurgical coking coal for making iron in the conventional blast furnace process. It is for this reason that the dispersal of steel plants, away from the coal belt in the Bengal-Bihar region, however eminently desirable, could not become a reality. The discovery of large reserves of lignite in Neyveli coupled with recent technological innovations have, however, dramatically changed the picture. The Consultants have now conclusively proved that a technically and economically sound Steel Project could be established with Salem ore using low temperature carbonised briquettes of Neyveli as reductant and electric power for smelting. The process recommended for steel-making in the Salem plant could very briefly be described as follows:

The Salem magnetite iron ore can be readily beneficiated to a high-grade concentrate analysing over 64 per cent iron. This would then be pelletised, prereduced in a rotary kiln and smelted to iron in electric furnaces. Lignite char from the briquetting and carbonisation plant at Neyveli would be used as a reductant in the prereduction kiln and smelting furnace. The liquid-iron so produced can be converted to steel by the L.D. process and then in continuous casting machines to produce blooms for rolling to finished products. Owing to the low sulphur and low phosphorus content, the Salem ore lends itself to the production of special grade iron and special types of steel with a variety of uses in high quality end products. This technology together with low assembly cost of raw materials at Salem permits the installation of a viable new steelworks in the region.

3. The Salem steelworks has several distinctive advantages even when compared to the existing steelworks in the country. The proposed location of the Plant at the iron ore mines coupled with the availability of large deposits of metallurgical grade of limestone, bauxite etc., at close proximity secures for this plant the advantage of the lowest raw material assembly cost in the entire country. The Consultants have estimated that about 161 ton-kilometres of transport alone would be required for assembling the iron ore concentrate, lignite

char and limestone per ton of steel at the Salem site. The transport requirements for the Salem Steel plant and the other Steel Plants furnished below provide a telling commentary on the situation.

Plant	*Transport requirements Ton Kms/Ton of steel ingot*
(a) Existing	
TISCO	592
IISCO	724
Rourkela	880
Durgapur	881
Bhilai	1617
(b) Proposed	
Neyveli—Salem.	161
Bokaro	842
Vizag	3090
Hospet	3298
Goa	4216

This phenomenally low raw material assembly cost would provide substantial saving in transport costs not to speak of avoidance of strain on our Railways on this account.

4. The proposed plant at Salem has easy access over broad gauge routes to the principal steel consuming centres in the Southern region like Madras, Bangalore, Coimbatore, Cochin and Tiruchirapalli. It is hardly necessary to point out the saving in freight on product distribution that would accrue by the establishment of this plant. At present, the Government of India have, with a view to promote balanced regional development, fixed a uniform price for the steel products at all railheads throughout the country. However, about 17 to 18% of the country's consumption in the Southern region is currently supplied over long leads from the existing plants in the North-Eastern region involving a freight charge of Rs. 45 to 55 per ton of pig iron. All these freight costs would be a substantial saving to the economy if the steel needs of the region are able to be met in a considerable measure by the Salem Steel Plant. Besides, the saving to the railways of the capital costs to haul the steel requirements of the Southern region from the existing steel works in the North-Eastern region would be of considerable magnitude. The regional dispersal would give significant relief to the already strained rail transport system in the country. A new steelworks in the region would also give a strong stimulus to the industrial advancement of the area. The Consultants have recommended in the product-mix various types of traditional items like light and medium structurals, merchant products, medium and light rails in which there are pronounced shortfalls in the country. What is more important, however, is the inclusion in the product-mix of such specialised items like spring steel, low alloy high tensile structural steel and gothic steel used in the seamless tube making industries all of which have a good market apart from their significance in a developing economy.

5. The consultants have also pointed out that the cost of production of Salem steel would compare very favourably with that of the existing steel works in the country. The overall yield of finished products from liquid steel using the continuous casting process recommended by the Consultants is estimated at 85% at Salem, which is about 10% higher than in the other steel works employing ingot practice and producing similar products. This favourable ratio of liquid steel to finished products in Salem is one of the principal factors contributing to the substantial reduction in production costs and has been made possible by the adoption of the recent technological advancements in steel works the world over. The plant at Salem will also have a very favourable per

ton plant cost when compared to the units of Hindustan Steel Ltd. The Report envisages an investment of Rs. 2,130 per annual ton of steel in the Salem plant as against Rs. 2,745 in Rourkela, Rs. 2,270 in Durgapur and Rs. 2,208 in Bhilai. Further the foreign exchange requirement of the Salem Plant is only about Rs. 38 crores out of an overall cost of Rs. 95 crores i.e., about 40%—which is a very favourable factor indeed.

6. This brochure presents the salient features of the seven-volume detailed project report in a non-technical language.

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CHAPTER II

STEEL DEMAND, INITIAL PRODUCT-MIX AND PLANT CAPACITY

1. A study of the steel demand in the country by 1970—71 and 1975—76 has been made by expert bodies like the Planning Commission and the National Council of Applied Economic Research. This is indicated in Appendix II.

2. According to this forecast, India's requirements will be 8 million tonnes of finished steel in 1965—66, 14 million tonnes in 1970—71 and 21 million tonnes in 1975—76 corresponding to 11, 18 and 28 million ingot tonnes respectively.

Additional steel capacity.

3. To meet the anticipated shortfalls, in addition to the establishment of Bokaro and the expansion of existing steelworks, the Government of India visualise the setting up of additional steel plants in three regions—the Neyveli—Salem, Goa—Hospet and Bailadila—Visakhapatnam regions.

Requirements of Neyveli—Salem region.

4. The future steel requirements of Madras State have been estimated partly by the end-use method and partly derived from forecasts for India. Steel requirements in 1965—66 have been largely derived from information on targets of investment and from targets of industrial production relevant for the State. Since similar data are not available for 1970/71 and 1975/76, the region's requirements have been projected to grow at about the same rate as those of the country

as a whole. The resultant picture of steel requirements in the Neyveli—Salem region is as below :—

FORECAST OF STEEL REQUIREMENTS IN NEYVELI—SALEM REGION

(in thousand tons)

Products	*1965/66*	*1970/71*	*1975/76*
Railway materials	76	104	139
Structurals	89	156	242
Merchant sections	200	348	536
Flat products	356	569	982
Other products	79	192	271
Total Finished Steel	800	1,369	2,170
Total Ingot Steel (million tons) (at approximately 1·33 times finished steel)	1·1	1·8	2·8

Initial capacity.

5. The initial capacity of the plant, based on the production of only section products to meet regional shortfalls in plain carbon steels and part of the all-India shortfalls in low alloy steels, is visualised at 0·5 million tons* per year. The product-mix suggested includes 50,000 tons of low alloy constructional steel, 50,000 tons of spring steel, 35,000 tons of low alloy high tensile structural steel and

* The Salem plant is designed to produce 5,00,000 tons per year of liquid steel, which will be continuously cast to 4,75,000 tons of 'semis'. In terms of 'ingot equivalent', this will be about 4,85,000 tons per year.

40,000 tons of gothic sections. The following table summarises the product-mix:

PROPOSED PRODUCT-MIX FOR SALEM PLANT

Product	*Plain carbon steels tons / year*	*Low alloy and special steels tons / year*	*Total tons / year*
Railway materials ...	37,500	—	37,500
Structurals ...	99,000	28,000	1,27,000
Merchant sections ...	1,13,500	1,07,000	2,20,500
Gothic sections ...	40,000	—	40,000
Total ...	2,90,000	1,35,000	4,25,000

Future expansion.

6. Taking into account the availability of raw materials, the expected rapid rise in the steel requirements of the southern region, and the possibility of the Salem plant contributing substantially towards meeting alloy steel requirements, provision has been made in the layout for rapid expansion to about 1·2 million tons in the second stage. If required, the plant capacity could be increased to about 3 million tons at a later date.

CHAPTER III

RAW MATERIALS

1. India possesses abundant reserves of high grade iron ore spread throughout the country. But her metallurgical coal resources are limited and confined to the Bengal-Bihar area. It would be uneconomical to transport large quantities of this coal over long distances to steel plants contemplated in the south, and it is, therefore, logical to base such plants on regional raw materials. **Need to use regional raw materials.**

2. Fortunately, new processes have recently been developed which can use different types of non-coking coals and lignite. Some of these have been used commercially for large-scale production. Tests carried out with Kanjamalai magnetite ore and Neyveli lignite have conclusively established their suitability for the economic production of iron by adoption of new technology.

3. The quantities of major raw materials required for the initial 0·5 million ton plant are given in the following Table: **Requirements of major raw materials.**

RAW MATERIAL REQUIREMENTS FOR SALEM

(0·5 million tons of liquid steel per year)

			Annual requirement (tons)
Iron ore (Kanjamalai magnetite) 36% Fe.		...	19,00,000
Lignite char	...	...	3,28,000
Limestone (iron making)	...	...	2,45,000
Limestone (steel making)	...	...	1,00,000
Magnesite ...	...	...	15,500

Possible iron ore sources.

4. In Madras State magnetite-quartzite iron ore occurs in the Salem and Tiruchirapalli districts, the estimated reserves being of the order of 370 million tons. The Kanjamalai deposit, situated about 12 km. away from Salem town, is amongst the more important ones in this region. The reserves have been estimated at 122 million tons.

Ore analysis.

5. On the basis of work done so far, the average analysis of the ore has been assumed as follows:

	Fe %	SiO_2 %	Al_2O_3 %	P %
Kanjamalai iron ore (1st band)	36·00	45·00	1·70	0·07

Kanjamalai ore suitable for concentration.

6. Extensive tests were carried out on the suitability of Kanjamalai iron ore for concentration by magnetic methods and pelletising of the concentrate thus obtained. From the tests it was established that the ore could be economically concentrated to over 64 per cent iron, and the concentrate so produced could be made into high grade pellets.

Lignite.

7. The plant has been based on the use of lignite char for the production of iron. The annual requirement for the initial 0·5 million ton plant is estimated at 3,28,000 tons.

Neyveli lignite char for Salem.

8. The South Arcot district of Madras State has large reserves of lignite, the estimated deposits being over 2,000 million tons. Presently lignite is being mined by the Neyveli Lignite Corporation. A carbonisation plant is under construction at Neyveli and its annual production capacity will be 3,63 000 tons of carbonised briquettes containing 15 per cent moisture, and 1,29,000 tons of minus 10 mm. char containing 20 per cent moisture. From this production all the minus 10 mm. fraction of 1,29,000 tons will be made available to the steel plant, the balance of 1,99,000 tons being met from carbonised briquettes.

Analysis of lignite

9. Lignite as mined contains about 50—60 per cent moisture and 20 per cent fixed carbon. Lignite char obtained by low temperature carbonisation of lignite briquettes contains lower ash and higher volatile

matter than coke from the Bengal-Bihar coals. The expected chemical analysis of lignite char is as follows:

	Per cent
Fixed carbon	71
Volatile matter	17
Ash	12
Sulphur	0·8
Calorific value (net)	6,600 Kcal/kg.

10. The second mine cut is expected to be completed by 1970. Out of a total of 7 million tons of raw lignite proposed to be raised, about 1·5 million tons will be allocated for the expansion of the steelworks.

Limestone

11. Limestone deposits occur all over India and the reserves of flux grade stone are estimated at over 2,000 million tons. In South India, limestone is found in the Cuddapah and Kurnool districts of Andhra Pradesh, the Chitaldrug, Shimoga and Tumkur districts of Mysore State and the Salem, Tiruchirapalli and Ramanathapuram districts of Madras State.

Sankaridrug deposits proposed.

12. The limestone deposits in the Sankaridrug, Namakkal and Tiruchengode taluks of the Salem district are proposed as the source both for iron and steelmaking. Most of these deposits occur within 20 km. from the Sankaridrug railway station which is 39 km. south-east of Salem on the Salem—Erode BG line.

13. The reserves may broadly be classified into three categories—flux grade containing insolubles less than 5 per cent, iron-making grade with 5-10 per cent and cement grade containing more than 10 per cent. The ironmaking grade occurs only at some places. The reserves of flux grade are estimated at 4·4 million tons and

cement grade at 46 million tons. By suitable blending of cement grade with flux grade, limestone averaging 9 per cent insolubles can be obtained for iron-making. The following analyses of limestone have been assumed:

	CaO %	MgO %	SiO_2 %	R_2O_3 %
Flux grade	50—54	1—3	1—3	0·3—0·5
Iron-making grade (30% flux & 70% cement grades)	44—48	1—3	8—10	0·5—1·5

Refractory raw materials.

14. The Neyveli-Salem region has no known reserves of refractory grade dolomite. However, dolomitic limestone occurs in parts of Mysore, Andhra Pradesh and Madras, but they are unsuitable for basic bricks for LD converters.

Magnesite lining for LD converters.

15. Magnesite bricks are therefore proposed for the converter lining. Salem is well known for its high grade magnesite deposits which are estimated at over 80 million tons. There are a number of developed mines which supply magnesite for refractory works and other steel plants in the country. The magnesite requirements of the Salem plant can be met from these mines.

Requirements of refractories.

16. The estimated refractory requirements are given below:

Construction	*Tons*
Fire bricks	9,000
Basic bricks	2,500
Insulation bricks	500
Total ...	12,000

Operation		Tons / year
Fire bricks	...	11,400
Basic bricks	...	500
Tar-bonded basic bricks (1)	...	7,500
Insulated bricks	...	100
	Total ...	19,500

Note : (1) Made at the steel plant.

17. Bulk of the refractories can be obtained from indigenous sources. In fact, with the changing pattern of consumption in the steel industry, brick making capacity at the end of the Third Plan is likely to be adequate to meet even the requirements of steel capacity in the Fourth Plan. Some special refractories may, however, have to be imported.

MISCELLANEOUS RAW MATERIALS

Manganese ore.

18. In South India manganese ore occurs in Mysore and Andhra Pradesh. The requirements of the plant can be met from deposits in the Tumkur district of Mysore State. These deposits are nearest to Salem.

Bauxite.

19. As supplies of metallurgical grade fluorspar are not yet developed in the country, bauxite will be used for steelmaking. For the Salem plant, bauxite is also required for ironmaking. These requirements are proposed to be met from Shevaroy hills around Yercaud which is 48 km. away.

20. Electrode paste required for self-baking Soderberg electrodes will come from Alwaye in Kerala State.

21. Bentonite is required in small quantities as a binder for balling the iron ore concentrate into pellets. Rajasthan has large reserves of sodium-based bentonite and the requirements of Salem can be met from this source.

Ferro-alloys.

22. Ferro-manganese will be readily available as capacity would be over 2,00,000 tons by the end of the Third Plan. Ferro-silicon can be obtained from the Mysore Iron & Steel Works where the capacity will reach 20,000 tons shortly. Aluminium pellets and copper can be secured from the market. Nickel and ferro-molybdenum have to be imported. Ferro-chrome and ferro-vanadium have also to be imported till such time as these are manufactured in India.

Cost of raw materials.

23. Estimated costs of major raw materials at the plant site are given in the Table below :

COST OF RAW MATERIALS FOR SALEM PLANT

Material	*Source*	*Cost at source* Rs. / ton	*Cost at plant* Rs. / ton
Iron ore (run-of-mine)	Kanjamalai	6·00	6·00 (1)
Lignite char	Neyveli		
+10 mm, 15% moisture		150·00	159·37
—10 mm, 25% moisture		50·00	59·37
Limestone	Sankaridrug	7·50	15·00
Manganese ore	Tumkur	32·00	51·00
Bauxite	Shevaroy	13·30	20·60

Note : (1) As the concentration plant is located at the mines, the cost of ore at source and the concentration are the same.

CHAPTER IV

PLANT LOCATION AND LAYOUT

1. *Plant Site*: After studying various sites in the Neyveli-Salem region, Kanjamalai (14 km. west of Salem town) is recommended as the most suitable site for locating the steel plant. Its advantages include favourable raw materials assembly cost, availability of water and power, and adequate BG and MG rail transport facilities providing ready access to sources of raw materials and to markets. **Kanja-malai site most suitable.**

2. Magnetite ore mined at Kanjamalai hill will be upgraded in a concentration plant located on the hill slopes, and the concentrate in the form of slurry will be pumped through pipelines over a distance of about 5 km. to the steelworks. Lignite char will be transported over metre gauge from Neyveli, 167 km. from plant site. Limestone will come from Sankaridrug by the Erode-Salem BG line.

3. A comparative study of assembling raw materials for the different locations indicates that about 161 ton-km. of transport will be required for assembling iron ore concentrate. lignite char and fluxes per ton of steel at the Kanjamalai site. This figure is the lowest amongst the sites considered for this project; also the lowest of all other steelworks in the country. **Material assembly cost lowest.**

4. The finished products from Kanjamalai have easy access over BG routes to Madras, Coimbatore and Tiruchirapalli, the three principal steel consuming centres in Madras State. Other areas linked by MG lines can be served on those routes. Small tonnages to places within 100 to 150 km. may be sent in truck-trailer combinations by road. **Access to markets.**

5. The water requirement for the steelworks including ore concentration plant is estimated at about 1,100 cu. m. per hour for the initial plant of 0·5 million tons. This can be readily met from the Mettur **Availabi-lity of water.**

reservoir on the Cauveri river about 27 km. north-west of the site. The same source can also meet the future requirements of the plant. The water requirements for the township and ancillary industries have not been included in the estimate. However, these requirements can be met from the same source.

Availability of power.

6. The maximum power demand for the steel plant is estimated at about 97 MW. This power will be available from the Madras grid and it is expected that there will be no difficulty in obtaining additional power to meet increased future requirements.

Land.

7. The plant proper will cover approximately 900 hectares and the area available at Kanjamalai is considered to be suitable from the viewpoint of earthwork in site preparation. About 10,900 hectares have already been notified for the plant, township, railway marshalling yards, ancillary industries and mining. Kanjamalai hill and other Government land within the project area comprise an additional 1 800 hectares. This area will be sufficient for plant expansion to 3 million tons. Acquisition proceedings according to a phased programme should be taken up at the earliest.

Sub-soil.

8. Observations made in unlined wells in different villages and other excavations in and around the area indicate that highly decomposed rock mixed with moorum occurs between two to five metres depth, below which lies slightly weathered rock. Load tests conducted in trial pits at Kanjamalai site indicate a minimum soil bearing capacity of over 3 kg. per sq. cm. at 3 m. depth in moorum and this is adequate to sustain heavy loads.

Compact layout.

9. The layout of the Salem plant differs basically from those of other steelworks with conventional coke ovens, mould yards, stripper yard, soaking pits and primary mills. The adoption of continuous casting makes the arrangement of plant facilities relatively compact.

Site preparation.

10. Alternative earthwork studies were made on the basis of the proposed facilities with a view to minimise the quantity of earthwork and the cost of site preparation. These indicated that different departments had to be located at different levels to suit the topography of the site. Also, only areas where structures, tracks and

other facilities are to be built should be levelled, leaving unlevelled patches in between. The study further showed that since the facilities for the initial and second stages were proposed to be located in the same area, it would be economical to take up the earthwork for both stages together. The total quantity of earthwork in site preparation is estimated at 3·69 million cu. m. cut and 3·53 million cu. m. fill.

Arrangement of major facilities.

11. Stockyards are laid along the Southern boundary adjacent to the incoming raw materials tracks. Calcining, pelletising, ironmaking and steelmaking facilities are laid parallel to the stockyards. The continuous casting machines discharge into rolling mills laid at right angles to the steelmelt shop. Such an arrangement eliminates tracks between the meltshop and the mills with the exception of one track for moving mill scrap and scale to the meltshop.

12. Repair and maintenance shops have been grouped in a separate zone towards the east with provision of space for future expansion. Two utility alleys are laid out, one running along each axis of the plant. The north-south alley will carry the main incoming power supply lines and the east-west alley will be used mainly for routing all water, oil, oxygen, air and steam lines. This will facilitate maintenance as also subsequent expansion.

Provision for expansion.

13. The layout and arrangement of various facilities have been so planned that expansion to 1·2 million tons can be expeditiously made and space provided for further expansion to 3 million tons, if required.

CHAPTER V

METALLURGICAL PRODUCTION PROCESS

1. The main consideration in the choice of processes and equipment is to achieve maximum economies in both capital and operating costs. Proved modern techniques and optimum-sized equipment have been adopted. Concentration of Kanjamalai magnetite and electric smelting with prereduction proposed for the Salem plant will be relatively new processes in this country. In addition, the adoption of LD converters with continuous casting makes a unique combination of modern technology at Salem.

Ore crushing and concentration.

2. The Kanjamalai magnetite ore averages 36 per cent iron and 45 per cent silica. This has to be upgraded for economic smelting. It is amenable to concentration by magnetic separation yielding a rich concentrate with good iron recovery.

Process flow sheet based on tests.

3. Laboratory and pilot plant tests in India and abroad have been carried out on Kanjamalai ore to determine its concentration characteristics. Based on test results, three-stage crushing of the run-of-mine ore (minus 1,200 mm.) to 0·3 mm. followed by single-stage wet magnetic separation is proposed, to obtain a concentrate of 64 per cent iron with about 78 per cent recovery. The concentrate will be further ground to minus 0·1 mm. to make it suitable for subsequent pelletising.

Plant and equipment.

4. The crushing and concentration plant has been located on the Kanjamalai hill slope close to the expected initial mining faces. About 1·9 million tons of run-of-mine ore will be processed to produce about 8,30,000 tons of concentrate. The primary and secondary crushers will handle this throughput in one shift and the same equipment can handle the requirements of the next stage of expansion by two-shift operation. The tertiary crusher and concentration equipment

will operate three shifts. Space is provided to add equipment and facilities for future expansion.

Pumping of concent-rate slurry.

5. A study of different methods of transporting concentrate to the steelworks over a distance of about 5 km. indicates that pumping in slurry form will be most economical. Meanwhile, tests to finalise the equipment design for slurry pumping have to be arranged.

Raw materials stocking.

6. To ensure uninterrupted operation of the steelworks in the face of fluctuating mine outputs, vagaries of transport and other unforeseen delays in raw materials supply, provision is made for stocking three weeks' requirements of lignite char and flux materials. As the plant is close to the iron ore mines, three days' stock of crushed ore and one week's stock of pellets are considered adequate.

Stocking and reclaiming facilities.

7. Two separate stockyards are provided—one for lignite char and other for fluxes and miscellaneous raw materials. Boom stackers will stock the materials in bedding piles and rotary wheel reclaimers will reclaim from the piles. This system ensures supply of materials of known and uniform analysis to the iron and steelmaking plants.

8. In the initial stage, about 2,100 tons of char, flux and miscellaneous materials will be required daily. The unloading, stocking and reclaiming facilities have been designed to handle this quantity conveniently in one shift. When the plant is expanded to 1·2 million tons, the same facilities will operate for two shifts. Space has been assigned for additional stockyards and necessary stackers, reclaimers and conveyor system.

IRONMAKING

Pilot plant tests.

9. Extensive pilot plant investigations were carried out in India and abroad to select a suitable ironmaking technique that could economically process the Neyveli—Salem raw materials. The testing

agencies and processes on which tests were conducted are given below:

Testing Agency	Tests on
National Metallurgical Laboratory, Jamshedpur, India ...	Low shaft furnace and electric smelting.
Unterwellenborn Research Institute, Freiberg. East Germany ...	Low shaft furnace.
Lurgi Gesselchaft fur Chemie und Huttenwesen, Frankfurt, W. Germany ...	SL Process.
Republic Steel and National Lead Corporation, New York, U.S.A. ...	RN Process.
Strategic—Udy Processes, Inc., Niagara Falls, New York, U.S.A. ...	Strategic—Udy Process.
Elektrokemisk A/S, Fiska Verk, Kristiansand, S. Norway ...	Electric smelting with prereduction.

Electric smelting prereduction proposed.

10. From the view-point of successful pilot plant tests based on Neyveli-Salem raw materials as well as the present status of development, electric smelting with prereduction is considered to be suitable. The investigations confirm that this technique would, compared to others, present less difficulties in commissioning the Salem plant and bringing production up to rated capacity in a short time. These factors are considered to be of significance under conditions prevailing in India today. Accordingly, electric smelting with prereduction based on the Elkem Tests is recommended for ironmaking at the Salem plant.

Features of the process.

11. The concentrate containing 64 per cent iron obtained from Kanjamalai ore will be pelletised and then prereduced in rotary kilns

using Neyveli lignite char as reductant. The required quantities of limestone, bauxite and manganese ore will also be charged into the kiln. Bauxite is required to maintain the alumina content of the slag at about 12 per cent for necessary fluidity.

12. The degree of prereduction achieved is expected to be 60—70 per cent. The hot prereduced materials from the kiln will be charged into submerged arc electric smelting furnaces. Prereduced hot charge substantially lowers the power consumption and significantly increases the output of the electric smelter. The char rate and power consumption are estimated at about 617 kg. and 1,000 kwh. per ton of hot metal. Basic iron suitable for steelmaking will be produced and its analysis is expected to be in the following range :

			Per cent
Carbon	(C)	...	2·5 — 3·5
Silica	(Si)	...	1·0 — 1·2
Manganese	(Mn)	...	0·75 — 1·0
Phosphorus	(P)	...	0·03 — 0·07
Sulphur	(S)	...	0·05 max.

Facilities have been designed for an annual production of 5,30,000 tons of basic iron. These include pelletising plant, prereduction kilns, electric smelters with gas cleaning system and pig casting machine.

Pelletising equipment.

13. Pellets, by virtue of their uniform size and high reducibility, are excellent charge material for the prereduction kiln and electric smelter. The annual requirement of pellets in the initial stage is about 8.15,000 tons. The concentrate will be pelletised in either pelletising discs or pelletising drums. The green pellets will be heat hardened in a grate-kiln unit or in a horizontal grate. Both types of equipment are equally good and comparable in capital and operating costs. Hence the final selection will have to be made at the engineering stage.

Prereduction kilns.

14. Four rotary kilns, one for each smelting furnace, have been provided for prereducing the pellets. The charge materials are

received by belt conveyors and stocked in the respective bins of each kiln. Materials drawn from the bins are weighed on belt scales and transported by a system of conveyors to feed the kilns.

15. The kilns are fired with smelter gas and fuel oil and the temperature is maintained at about 950°C. The throughput of each kiln is 40 tons of pellets per hour. The hot discharge is collected in refractory-lined charging buckets and hoisted to the top of the smelting furnace for charging.

Electric smelting furnaces.

16. Four 17·5 MW, submerged-arc, Tysland-Hole type electric smelting furnaces, each with a capacity of about 400 tons of hot metal per day, are proposed. This is in line with the largest electric furnaces with prereduction kilns under construction at Skoplje in Yugoslavia. Each furnace is equipped with a 26 MVA. transformer. The furnace gas after wet cleaning is used in the kiln. Hot metal is tapped in 70-ton open top ladles and transferred into 150-ton torpedo ladles for supply to steelmelt shop. Slag is removed in pots and transported by rail to dump.

Pig casting machine.

17. One double-strand pig casting machine with a capacity of 75 tons per hour has been provided to handle hot metal supplied in 70 ton ladles. About 20,000 tons of off-grade iron per year will be cast into pigs. The cold pigs will be sent to open stockyard where they will be manually handled.

LD Process recommended.

18. Top blown oxygen steelmaking (LD) process has been recommended because of its low capital and operating costs. Its versatility for producing low alloy, high carbon and other special steels is particularly suited for the Salem product-mix. The regular tapping of the heats at short intervals makes this process ideal to work in conjunction with continuous casting installations. Further, it is readily adaptable to computer control.

19. Two 60-ton LD converters (one operating) have been proposed to meet the annual requirement of 5,00,000 tons of liquid steel. The converters will be lined with magnesite bricks. A calcining plant with one 70-ton per day rotary kiln for calcining magnesite for brick making and two 100-ton per day shaft kilns for

production of burnt lime has been provided. Necessary brick making facilities are included.

LD gas to be collected.

20. The lack of by-product gases, due to the absence of coke ovens and blast furnaces at the Salem plant, necessitates the collection of LD converter gas. A number of gas collection systems have been developed—the IRSID—CAFL system in France, the OG system in Japan and the KRUPP system in Germany. From the point of view of safety and operational experience the OG system (Oxygen Gas collection) is preferred. Other systems may also be considered during the engineering stage. Approximately 34 cu.m. of gas per ton of liquid steel will be collected. This gas, with an average calorific value of 2,200 kcal per cu.m., will be consumed in the meltshop for miscellaneous heating purposes.

Special steels to be vacuum degassed.

21. Vacuum degassing of steel which offers significant metallurgical advantages has been proposed for treating special steels at Salem. This facility will be the first of its kind to be adopted in Indian steelworks. Vacuum degassing has been developed in recent years primarily to reduce hydrogen content and flaking tendency in quality steels made in large tonnages. It also removes part of the nitrogen and oxygen, thereby resulting in higher alloy recovery and cleaner steel with improved ductility.

DH Process proposed.

22. The vacuum lift method of progressive degassing developed by Dortmund-Horder Huttenunion AG (DH) has found wide acceptance. A DH installation to treat 50 to 80 ton heats has been provided in the steelmelt shop. Only rail, spring and low alloy constructional steels will be degassed.

Continuous casting.

23. Application of continuous casting technique has eliminated several steps associated with conventional ingot practice. This has reduced investment and operating costs and substantially improved the yield of finished product from liquid steel by about 10 per cent. The process has now reached a stage of development justifying its consideration for adoption in large steelworks.

Continuous casting for Salem plant.

24. Continuous casting is well suited for handling killed* and low alloy steels to be produced at Salem for which the latest type of 'S'

* Steel which has been fully deoxidised.

machine has been proposed. Three 4-strand machines for casting blooms in sizes 150 × 150 mm. 200 × 200 mm. and 300 × 250 mm. are provided in the casting aisle of the steelmelt shop. The entire production of 5,00,000 tons of liquid steel will be cast through these machines. Siphon type ladles for lip pouring will be used.

Rolling mills.

25. The rolling mills complex is designed to roll exclusively section products. The facilities comprise a break-down mill, a section mill and a merchant mill of modern design. Optimum-sized mills have been selected for the proposed production and over 80 per cent of mill capacities will be utilised. A common roll shop serves all the mills.

Breakdown mill.

26. The breakdown mill reduces the continuous cast blooms to smaller sizes suitable for rolling in the finishing mills. The proposed sizes and tonnages of blooms could be rolled in a 2-high reversing mill or a 3-high mill. To suit the requirements of rolling breakdowns from the large starting bloom sizes, a 2 high reversing mill will be more economical. It also offers greater flexbility of operation and ease of maintenance.

27. Accordingly, a 750 mm. 2-high reversing mill is recommended along with three 50 tons per hour, 4-zone continuous pusher type bloom reheating furnaces to take care of blooms up to 8 m. in length.

Section mill.

28. The section mill is required to roll about 1,57,000 tons of light rails and structurals per year. This production requirement does not justify the installation of a high cost, high production continuous or combination of continuous and cross-country type mills, A three-stand mill consisting of two 3-high roughing and one 2-high finishing stands is considered adequate to provide 8 to 10 passes required for rolling rails and structural sections from blooms and blanks supplied by the reversing breakdown mill. A 3-high stand for each roughing unit has been proposed in preference to a 2-high stand for reasons of economy and simplicity in rolling with less turning. The size of the mill will be 650 mm. to suit the sections to be rolled.

29. Accordingly, a section mill with two 3-high 650 mm. roughing stand and one 2-high 650 mm. finishing stand has been recommended.

Merchant mill.

30. The merchant mill is required to roll about 2,40,000 tons of billets into 2,28,000 tons of finished product. The billets received from the breakdown mill are to be rolled in straight lengths for all merchant sections except for rounds from 5 to 10 mm. which will be finished in coil form.

31. Merchant mills are usually of the cross-country, semi-continuous or continuous types. A cross-country mill is economical and suitable for small production requirements. The semi-continuous mill usually has a continuous roughing train followed by a cross-country intermediate train and continuous finishing train. This type of mill is handicapped by the fact that the cross-country stands have to be fed by repeaters for rolling rounds and this involves twisting which is detrimental to alloy steel rolling. Further, for rolling sections such as beams and larger angles, the cross-country stands have to be fed from a Y-table which restricts the bar length due to cooling down of the stock. This in turn limits the starting billet size and thus the mill output. The continuous mill is suited for large production because the straight line arrangement permits high finishing speeds and fast rolling rates. The short time interval between passes ensures better tolerance of the rolled product.

32. On the above considerations a 26-stand merchant mill has been recommended. It will consist of a continuous roughing train with four 460 mm. and four 420 mm. 2-high stands, a continuous intermediate train with seven 380 mm. 2-high stands, a finishing train with five 340 mm. 2-high stands and two groups of continuous wire rod finishing train each with six 280 mm. 2-high stands.

CHAPTER VI

POWER, UTILITIES AND AUXILIARY SERVICES

Availability of power.

1. *Power:* Electric power for the steel plant has been assured from the Madras State Electricity Board power grid which, as planned, will have sufficient capacity to meet the steelworks power requirement. All major stations—Kundah, Mettur, Neyveli and others—are inter-connected over 220 and 110 kv. transmission lines and the total system capacity would be about 970 MW by 1965, and is expected to increase to 1,140 MW by 1967.

Works power requirements.

2. It is estimated that for the initial plant capacity the maximum demand will be about 97,200 kw. Of this, electric smelting furnaces will account for about 67,300 kw. The annual load factor for the entire plant will be about 86 per cent, while the annual load factor of the electric furnaces alone will be about 90 per cent.

Nature of power system.

3. The entire power will be purchased from the Madras State Electricity Board (MSEB) at 110 kv. and stepped down to 11 kv. for the plant underground distribution system. Power distribution in the steelworks is essentially by a radial feeder system. Duplicate full capacity feeders are provided to ensure maximum continuity of power supply in the case of major departments, where interruptions of electric supply may cause serious loss of production.

4. The crushing and concentration plant is situated at about 7 km. from the main receiving station. The 11 kv. power will be stepped up to 33 kv. and the feeders carried underground within the plant boundary and overhead for the rest of the route. Duplicate full capacity overhead feeders are proposed for maximum continuity of operation.

Power tariff.

5. During discussions with MSEB it had been indicated that the steelworks could purchase power on two separate tariffs—one

for electro-metallurgical purposes only and the other for the rest of the steel plant, the two power blocks being metered separately. However, it is desirable to reach an agreement with MSEB to determine the tariff for the Salem plant, on the basis of average unit rate, based on monthly maximum demand and metered at one point. This would simplify works power system, as metering two separate power demands requires complete isolation of the two power blocks which would create difficulties in system planning when power is metered at 110 kv.

6. As advised by the Madras Government, the average unit cost of Rs. 0·03 per kwh. has been assumed in this report.

Water supply.

7. *Utilities:* The Stanley reservoir at the Mettur Dam on the river Cauvery, about 27 km. to the north-west of plant site, has been proposed as the main source of water for the steelworks. Raw water from the reservoir will be pumped to head-works to be located on Sitamalai hill, about 7 km. (along the pipeline alignment) towards the plant site. Here the water is clarified in a treatment plant and then gravitated to the steel plant over a distance of about 25 km. (along the pipeline alignment). The make-up water required for the steelworks, including the concentration plant located on the Kanjamalai hill, is approximately 1,100 cu.m. per hour which is about 10 per cent of the total water in circulation. The average water consumption per ton of finished steel is about 19 cu.m.

8. Filtration, chlorination, demineralisation and distillation facilities are located inside the steelworks to treat the water to required qualities. In order to conserve water, five main circulating systems of closed or semi-closed type have been provided, four of them inside the works and the fifth at the concentration plant. All systems, except the one at the concentration plant, are provided with induced draught cooling towers. The concentration plant system includes the water for pumping concentrate slurry and disposal of tailings.

Construction water.

9. Construction water during the peak period is estimated at about 130 cu.m. per hour. This requirement is proposed to be met from wells dug near the construction areas. The availability of well water at the required rate even during the driest season needs to be investigated.

Fuel system.

10. The fuel system at the Salem plant varies from those in other integrated steelworks where the heating requirements are generally met by by-product gases from the coke ovens and blast furnaces. The pattern of fuel consumption at Salem is different due to the adoption of electric smelting, LD steelmaking and continuous casting facilities.

11. The only by-product gases available are small quantities from the smelters and LD converters. The plant fuel balance indicates a deficit equivalent to 1,06,000 tons of fuel oil per year. Arrangements, therefore, are to be made with the proposed Madras or Cochin refineries for the supply of this quantity. The railway authorities concerned have to be contacted for provision of necessary tank wagons for movement of the oil. The total energy requirements expressed in terms of standard coal (6,925 kcal per kg.) are estimated at about 1·20 tons per ton of finished steel.

Oxygen and acetylene.

12. Two 100-ton per day oxygen generating units are proposed to meet the steelmelting, continuous casting and general purpose requirements. The oxygen plant will also produce nitrogen required for the LD gas recovery system and the vacuum degassing unit. Facilities for storing 600 tons of liquid oxygen to meet emergency requirements and 8,000 cu.m. of gaseous oxygen under pressure to balance demand fluctuations have also been provided. Oxygen in cylinders required for miscellaneous use will be available from a cylinder filling station with arrangements to fill 50 cylinders per day. Acetylene requirement of about 150 cu.m. per day is proposed to be purchased from outside sources.

Steam.

13. As no works power generation is envisaged, steam generation capacity is planned only to meet process steam requirements. Two oil-fired boilers, each with a normal steam raising capacity of 6·5 tons per hour at 14 atm and 220°C, have been provided.

Compressed air.

14. The compressed air requirements of the various departments will be met from three stations located in suitable zones in the works. All compressors will be standardised on a size of 1,700 cu.m. per hour at 7 atm.

15. *Auxiliary facilities*: A central as well as seven area laboratories will cover all the laboratory and inspection services needed for the steelworks. The central laboratory consists of a metallurgical section and a chemical section. The metallurgical section provides destructive, non-destructive and other conventional testing facilities. It undertakes all development and investigation work including sales complaints and plant failure problems. The inspection and process control section is responsible for inspection of products and quality control. The chemical section carries out all tests other than those done in the area laboratories. Library, information service, conference room and projection facilities are available in the central laboratory. **Central and area laboratories.**

16. Routine chemical analysis and specific tests required by the production departments are carried out by the respective area laboratories. The steelmelt shop laboratory is equipped with a modern direct reading spectrometer. A pneumatic tube system links this laboratory with LD converter stage for rapid transmission of test samples.

17. Adequate repair and maintenance facilities are essential to minimise production delays caused by breakdown of equipment. The need for such facilities within the works is emphasised by the difficulties encountered in securing spare parts both from local and foreign sources. While planning for repair and maintenance shops for the Salem plant, the possibility of gettting some services from the heavy engineering units now under construction and from small-scale manufacturing and fabricating units likely to grow in Madras State has been kept in view. **Repair and maintenance shops.**

18. The repair and maintenance shop consist of ten central workshops housed in six buildings and five area workshops at the major production departments. The central workshops have been laid out on one side of an open stockyard serviced by a Goliath crane to permit rapid handling and easy inter-shop movement of materials. Space has been provided for expansion of individual shops and also for building additional shops.

19. After the construction of the initial stage is over, the construction yard facilities will be utilised for the central stores **Central stores.**

complex. When the second stage of construction commences, a new stores complex will be built in the area assigned next to the maintenance shops and the construction yard released for construction purposes.

Miscellaneous facilities.

20. Other facilities include general administrative office, general superintendent's office, area offices for the plant departments, technical training institute, canteens, first-aid station and security and fire-fighting services.

Sewerage.

21. The sewerage system is planned to meet the needs of the plant including its expansion to 1·2 million tons. The design allows for peak flow during change of shift and for additional load from construction labour. Sewage is carried to the treatment plant mainly bv gravity. Pumping stations have been installed wherever depth becomes excessive or rock is encountered. The chlorinated effluent from the treatment plant will be discharged into the Sarabunga river.

Drainage.

22. A common drainage system for storm water and industrial waste water has been provided. The system can handle the load of the plant when expanded to 1·2 million tons. The water is let into Sarabunga river without treatment.

CHAPTER VII

MANPOWER AND PLANT MANAGEMENT

Manpower requirement.

1. *Recruitment*: Preliminary estimates of manpower, prepared for the purpose of estimating production costs indicate that about 5,000 men will be required to operate the 0·5 million ton plant. Department—wise manpower estimates including reserves for leave, holidays and absenteeism are summarised below:

MANPOWER REQUIREMENTS FOR SALEM STEELWORKS

	Total men on pay roll
Iron and steelmaking	1,385
Rolling mills	1,327
Repair and maintenance shops... ...	629
Electrical services	250
General services	643
Laboratories	215
Administrative and other services ...	592
Total ...	5,041

2. The above estimates are based on a preliminary study of the operations. While fixing the standard force for department, systematic industrial engineering studies will have to be undertaken on the basis of the equipment, layout, handling methods, automation and other facilities as finally provided.

3. Manpower requirements have been estimated under three heads—supervisory and clerical, operating labour and maintenance

labour. Shift-wise manning has been worked out on the basis of four shifts to arrive at the number of men required on any working day. To this figure has been added a provision to cover (a) the needs of departments working continuously for 7 days of the week, (b) 15 per cent extra staff to make up for those on leave or otherwise absent and (c) relief personnel statutorily required for such jobs as crane drivers or for jobs involving continuous work in high temperature environment.

Unit labour cost.

4. Hindustan Steel Limited pay scales have been assumed and to this 50 per cent for bonus payments and 15 per cent for statutory benefits like provident fund have been added to obtain the total salary bill. On the basis of 272 man-days per year, the average unit labour cost for the plant works out to Rs. 2·50 per man-hour.

Category-wise breakdown.

5. The tentative distribution of manpower by categories of personnel is presented below:

CATEGORIES OF PERSONNEL REQUIRED

Category	*No. of men required*
Senior engineers	88
Junior engineers	305
Operatives and artisans	3,013
Semi-skilled workmen	1,082
Administrative and other service personnel..	553
Total ...	5,041

Recruitment.

6. The phasing of recruitment and manning based on the estimated manpower requirements and the construction schedule is summarised below:

TENTATIVE RECRUITMENT AND MANNING SCHEDULES

(Cumulative totals of personnel)

	Recruitment	*Manning*
End of 1st year ...	750	50
End of 2nd year ...	2,600	200
End of 3rd year ...	3,400	1,250
End of 4th year ...	5,000	5,000

7. The need for competent personnel at the required time and in the required number emphasises that preparatory steps for recruitment should be taken up early. Recruitment and training have to be so organised that the skilled personnel and supervisory staff are in position 3 to 6 months ahead of the start up of each plant. This will enable them to participate in the final stages of erection and commissioning. The main preparatory steps include the preparation of detailed manning lists and job specifications; setting up a rational wage structure, assessment of the availability of requisite personnel for the Salem plant in the light of competing demands from other sources, preparation of a recruitment programme and time schedule keeping in view the training requirements of various categories of personnel; and the phasing of plant construction, and establishing scientific personnel selection methods. **Preparatory steps.**

8. *Training*: Of the 5,000 men required, 3,500 are estimated to be in skilled positions. Of these, 2,800 will be given varying periods of training.

9. Early steps have to be taken to prepare detailed training programmes according to categories of personnel, types of jobs, centres of training, and periods and types of training. Job-oriented and on-the-job training are essential to ensure smooth and rapid attainment of full production.

10. The training facilities available now in the country can largely meet the needs of the Salem plant. Those assigned for LD converters, rolling mills and maintenance shops can be trained in existing steelworks and in the technical institutes attached to them. To supplement these facilities work on the proposed training institute for the Salem plant should also be initiated as soon as further work on the project is started. **Training facilities.**

11. Although most of the personnel will be trained in India, a limited number have still to be trained abroad in such relatively new techniques as magnetic concentration, pelletising, electric smelting with pre-reduction, L D gas recovery, vacuum degassing and continuous casting. It is estimated that about 50 persons consisting of managerial, supervisory, operating and maintenance staff will have to be sent abroad. **Foreign training.**

12. *Plant management*: Considerable amount of industrial management experience now exists in the country largely developed since Independence. Many of the industrial units both in the public and private sectors are known for efficient management and it should be possible to recruit competent personnel with industrial experience.

13. Delegation of authority should be adequate to enable line management to function in a production-oriented manner. This should cover recruitment of personnel, fixation of wage scales and enforcement of discipline.

Foreign personnel.

14. Where Indian personnel with requisite experience are not available, services of foreign personnel have to be secured. It is estimated that about 10 foreign technicians would be required for a period up to one year primarily for the new processes. Competent men have to be selected and provided with Indian understudies so that the eventual take-over is smooth.

CHAPTER VIII

PLANT CONSTRUCTION—CONSTRUCTION SCHEDULE AND CONSTRUCTION MANAGEMENT

1. Experience in steel plant construction gained over the past 10 years and the services of many engineering firms developed during this period will be available for construction of the Salem plant.

4½ year period of construction.

2. The period of construction visualised for the initial stage is about four and a half years from the date of authorisation to proceed. Construction is so scheduled that two out of the four electric smelters along with the concentration and pelletising facilities will be the first to be commissioned in about 44 months. The pig iron produced will be sold till such time as one LD converter, two continuous casting machines, breakdown mill and merchant mill are brought into operation. The remaining iron and steelmaking facilities will follow and the last unit to go into operation will be the section mill at the end of the construction period of 54 months.

3. *Preplanning to reduce construction time*: To adhere to the construction schedule, it is essential that the project be preplanned in detail before intensive construction work is started at site. This would enable the work on site preparation, laying of construction facilities and off site facilities to be completed in time. In addition, indigenous manufacturing capacity will have to be investigated and mobilised well in advance. Such planning would reduce the overall construction time and enable increased use of indigenous equipment and services.

Separate administrative machinery.

4. The creation of a separate administrative machinery for the project would help speed up planning and construction. The tendering procedures and contractual documents should then be finalised and the specifications on major plant and equipment issued there-after.

About three to six months time will be allowed for preparation of bids and submission of tenders.

Agencies involved.

5. *Construction management:* To ensure efficiency, construction management will have to be organised on a sound basis by determining and delegating specific responsibilities, duties and functions and by firmly establishing necessary authority to different agencies entrusted with the work on the project. The agencies involved will be;

(i) *Client*: The Salem Steel Plant organisation, delegated with necessary authority by the Government.

(ii) *Consulting Engineers*: The agency entrusted with the design and engineering services, including supervision of construction and erection.

(iii) *Equipment Suppliers:* Foreign/Indian manufacturers and suppliers of equipment and structurals.

(iv) *Contractors*: Indian contractors for executing civil and Structural work and plant erection.

6. The management pattern visualised for undertaking the engineering, supply of equipment, construction and erection is based upon utilising maximum indigenous supplies and services. Foreign equipment suppliers will be responsible for the supply of integrated equipment (including the indigenous portion), commissioning of such equipment and usual performance guarantees. The suppliers will also furnish equipment loads, area requirements and other relevant data for the preparation of foundation drawing and utilities layouts in India, and their execution at site by Indian contractors. Erection of plant and equipment will be carried out by Indian contractors under supervision of erectors normally provided by equipment suppliers. Foreign equipment suppliers will also arrange for training facilities in the maintenance and operation of specialised equipment.

7. The Consulting Engineers will assume technical responsibility for designs, provide engineering services, and integrate the various activities into an efficient project.

8. *Mobilisation of Indigenous capacity*: A large indigenous manufacturing capacity already exists within the country which can be mobilised to supply the Salem steelworks with a substantial proportion of the structurals and refractories and such items of equipment that are locally available. Emphasis has been laid on the maximum possible use of such locally available services, supplies and equipment, not only to reduce the foreign exchange component but also to encourage Indian engineering.

Maximum reliance on indigenous suppliers.

9. It is estimated that out of the 55,000 tons of structurals required for Salem, about 75 per cent can be fabricated in India. This requires advance action to be taken sufficiently early to book fabricating capacity of about 1,500 tons per month for a period of 30 months, and to arrange for requisite supplies of steel to the fabricators. For this purpose, it will be necessary to initiate procurement of typical steel sections based on preliminary designs and provide assistance to fabricators to augment their facilities. In view of the complex nature of steelwork in various plant structures, it is advisable to entrust the erection of such buildings to the agency responsible for structural steel fabrication. This will facilitate co-ordination of erection work and field changes. Arrangements should also be made for the import of the required tonnage of raw or fabricated steel which are in short supply.

Fabricated structurals

10. It is expected that major structural and machanical components of cranes below 40 tons capacity will be procured in India. Heavyduty cranes and electrical equipment will have to be imported. Machine tools, pumps, switch-gear, transformers, wagons, trucks, weighbridges, conveyors and such other equipment locally available will be procured indigenously.

Equipment.

11. The total refractories required for construction, estimated at about 12,000 tons, will largely be obtained within India from local manufacturers. Certain special items may have to be imported.

Refractories.

12. The main factor determining the allocation of foreign exchange and Rupee costs for the Salem plant is the extent to which equipment and supplies can be procured locally in India within the time available as determined by the delivery periods visualised in the construction schedule. The estimates presented in the report are based

Main plant and equipment.

on indigenous procurement of bulk of refractories, fabricated structurals, and a part of the mechanical and electrical equipment. The main plant and equipment for crushing and concentration, pelletising, ironmaking, steelmaking, continuous casting and rolling mills will have to be imported.

13. Estimated FOB prices of equipment to be imported include costs of packing, tools and tackles, erectors and commissioning services, and commissioning spares normally provided by the suppliers. It may be noted that equipment costs are based on budgeting prices quoted by European and Japanese suppliers.

14. An indication of the quantities of the principal items involved in civil construction is given in the table below:

APPROXIMATE QUANTITIES OF PRINCIPAL ITEMS

Earthwork in site levelling—cut/fill ...	36,90,000 cu. m.
Excavation in foundations	13,00,000 ,,
Concrete	3,35,000 ,,
Structural steelwork	55,000 tons
Refractory work	12,000 ,,
Equipment erection	80,000 ,,
Roads	15 km
Railway track	62 ,,

Offsite work to be expedited.

15. Simultaneously with construction at site, it is essential that work on offsite facilities such as railway, marshalling yards, external water system, power supply, township, construction water, and power and housing for construction personnel be taken up.

CHAPTER IX

CAPITAL COST AND PRODUCTION COST ESTIMATES

1. *Capital cost:* The capital cost for the initial 0·5 million ton plant is estimated at Rs. 955 million with a foreign exchange component of Rs. 386 million or about 40 per cent. A summary of the capital cost is given below:

SUMMARY OF PLANT CAPITAL COST

Cost item	*Foreign currency* '000 Rs.	*Indian currency* '000 Rs.	*Total* '000 Rs.
Civil works ...	—	1,61,063	1,61,063
Structural steelwork ...	26,574	76,101	1,02,675
Equipment ...	2,97,427	82,592	3,80 019
Total erection ...	—	68,751	68,751
Spares	29,743	8,259	38,002
Customs duty ...	—	68,768	68,768
Freight and insurance ...	14,149	25,611	39,760
Project administration, design, engineering, procurement and supervision of construction ...	—	50,000	50,000
Sub-total ...	3,67,893	5,41,145	9,09,038
Contingency 5 % ...	18,395	27,057	45,452
Total ...	3,86,288	5,68,202	9,54,490

Offsite costs excluded.

2. Capital cost estimates include customs duty, provision for spares, project administration, engineering and contingency. Cost of recruitment and training, capitalised interest and offsite costs on township, mines and quarries and water supply are excluded.

Incidental charges.

3. Essential spares specially for the imported equipment will be purchased along with the main plant. For this purpose, a provision of 10 per cent of the equipment cost has been made in the total capital cost estimate. Customs duty on imported equipment varies widely depending on the equipment and is subject to change from time to time. An average of about 18 per cent of the C I F value has been added to the import price.

4. Capital costs also include expenses of project administration during construction which cover security, store keeping, supervision at site and of offsite developments, and erection insurance. Fees for design, engineering and supervision of construction and erection services are also included. A contingency fund of 5% of the total plant cost has been provided.

Comparison of capital cost.

5. Salem's capital cost is compared with those of Hindustan Steel Limited plants (at their initial capacities) in the following Table. For uniform comparison, only plant costs are considered in all cases, excluding cost of spares, deferred charges capitalised interest, mines, quarries, township and other works outside the plant boundary.

COMPARISON WITH HSL STEELWORKS

Plant	*Initial finished steel capacity tons / year*	*Investment Rs. / annual T*
Rourkela	7,20,000	2,745
Durgapur	7,90 000	2,270
Bhilai	7,70,000	2,208
Salem	4,25,000	2,130

6. The investment cost per ton of finished steel at Salem is favourable mainly due to the adoption of continuous casting process which eliminates expensive teeming, stripping, soaking and primary mill facilities. As lignite char will be received from Neyveli, no carbonisation facilities have been included. On the other hand, a crushing and concentration plant for concentrating the iron ore has been provided.

7. *Production cost:* Production cost estimates indicate that these are comparable with the costs of similar products in the existing steelworks. In addition, the alloy and special steels, which form about 32 per cent of the Salem products, would realise higher sales value and add to the profitability.

Salem cost comparable with other steel plants.

8. Estimates of production costs have been developed under two heads—'Materials Cost' and 'Cost Above Materials'. The 'Materials Cost' represents the cost of materials allowing for the yield involved in the process, to convert the materials into one ton of good product. The 'Cost Above Materials' covers all other items of expense incurred in processing the materials, such as labour, fuel, power, repairs, maintenance, etc. General plant and administration expenses, including the deficit on township, have also been covered under 'Cost Above Materials'.

9. The overall yield of finished products from liquid steel, using continuous casting is estimated at 85 per cent at Salem. This is about 10 per cent higher than that in other steelworks employing ingot practice and producing similar products. This high yield is the major factor contributing to substantial reduction in production costs.

High yield.

10. The production costs of various finished products are summarised in the Table below. Fixed charges and excise duty are not included. The current rate of excise duty applicable to these products is Rs. 90 per ton.

ESTIMATED PRODUCTION COST AT SALEM

(excluding fixed charges and excise)

Finished Product	*Cost of product Rs. / ton*
Rail 24 to 60 lb. / yd.	361
Fishplate—for rails upto 105 lb. / yd. ...	422
High carbon spring steel	365
Si-Mn spring steel	398
Cr-V spring steel	468
Low alloy constl. & machinery steel—various sections	475 to 514
High tensile structural steel—various sections ...	378 to 405
Plain carbon steel—various sections ...	318 to 344

11. There is further scope to reduce the production cost by possible reduction in the cost of char and by using duty-free naphtha in place of fuel oil. The total requirements of char for the steelworks can only be partly met by the minus 10 mm. char fines at Rs. 50 per ton from the Neyveli Carbonisation Plant. The balance will have to be drawn from the plus 10 mm. char briquettes at a cost of Rs. 150 per ton as indicated by the authorities. These prices have been assumed for working the production costs. However, the price of plus 10 mm. char briquettes is considered even higher than that of metallurgical coke which would cost not more than Rs. 100 per ton F.O.R. Salem. It would be, therefore, necessary to review the price of plus 10 mm. char briquettes and bring it down to a realistic figure of say Rs. 100 per ton. This would result in lowering the production cost by about Rs. 23 per ton of finished steel.

12. The plant fuel requirements are proposed to be met by purchasing fuel oil at about Rs. 180 per ton. Fuel oil can be substituted by petroleum naphtha available from the oil refineries. Currently the requirements of naphtha for fertiliser plant and for injection in blast furnaces are exempted from excise duty. If similar exemption could be obtained for the Salem plant requirements, the cost of naphtha would be cheaper than that of fuel oil. This would effect a further reduction in the production cost per ton of steel.

Conclusion.

13. The proposed Salem Steelworks presents the opportunity of opening up new industrial horizons in the rapidly developing Southern region of the country. Compared to other Indian steelworks, Salem has the advantage of lowest raw material assembly and product distribution costs. The available raw materials can be utilised with advantage through the application of new technology to produce quality products at competitive costs.

APPENDIX I

TERMS OF REFERENCE

The scope of work on the detailed project report is based on Sections I to IV of the Agreement with the President of India dated 8th February, 1963, reproduced below:

I. As from the Eighth day of February 1963 the Consulting Engineers shall be employed in the manner and for the purpose hereinafter specifically set out, as Consulting Engineers, for preparing the Detailed Project Report together with necessary details and drawings for establishing in the State of Madras a highly efficient and modern low-cost producing iron and steelworks (hereinafter referred to as the "Works") with an initial capacity of 3,00,000 to 5,00,000 metric tonnes of ingots per annum, converted into finished rolled steel products, and capable of further expansion to the extent found desirable by the Government.

II. The Works shall consist of the following principal Departments subject to such change as may be agreed upon by both the parties in the course of examination and preparation of the Detailed Project Report to be submitted by the Consulting Engineers:

(*a*) Lignite processing plant;

(*b*) By-products plants;

(*c*) Beneficiation and Sintering plants;

(*d*) Furnace depending upon the process recommended and ancillary equipment to produce pig iron;

(*e*) A steel making plant of annual capacity of 0·3 to 0·5 million metric tonnes including Auxiliary Plant, Mould and Scrap preparation plants etc ;

(*f*) Facilities for casting, handling and stripping ingots ;

(*g*) Soaking pits for requisite capacity ;

(*h*) A Blooming / Slabbing Mill with suitable capacity ;

(*i*) Suitable facilities for manufacturing finished products ;

(*j*) All necessary ancillary plant and services required for the efficient and economical operation of the Works, such as transport system, Blowing and Power Plant, Gas, Water and Steam System, Electrical distribution, Central and Subsidiary Stores, Laboratories and Administrative Office etc ;

(*k*) Central Engineering Department for maintenance purposes, comprising :

(*i*) Iron, Steel and non-ferrous materials processing and pattern shops ;

(*ii*) Maintenance workshops for all necessary trades including Locomotive and Wagons maintenance shops.

III. The Consulting Engineers shall prepare a Datailed Project Report for the Project which shall contain, besides other details, relevant and necessary information for the Government to take informed decisions on the location of plant, general layout, equipment and processes, including the following :

1. PLANT LOCATION STUDY

Study factors affecting the location of the plant such as availability of raw materials, water, power, etc., at three or four possible plant locations in the Neyveli—Salem area, in consultation

with local authorities, and recommend suitable locations. An interim report on the location shall be submitted by the Consulting Engineers by 31st May 1963 to enable the Government to commence land acquisition proceedings and other preliminary work at site.

2. DETERMINATION OF PLANT CAPACITY AND PRODUCT-MIX

Depending upon the regional demand for steel, the supply position from existing sources and the type of process to be adopted, suggest the initial capacity and product mix for the plant, bearing in mind:

(a) The optimum capacity of the plant and equipment selected.

(b) Probable subsequent expansion of production.

3. RAW MATERIALS

An appraisal of the proposed sources and availability, physical and chemical characteristics and prices of the following raw materials, based on reports and any further work that the Consulting Engineers may consider necessary.

(a) *Iron Ore*—Consider possibility of utilisation of Salem Magnetite deposits and advise on the economics of using the Bellary-Sandur ore as against beneficiated Salem ore.

Study available data on beneficiation tests on Salem magnetite ore and suggest further tests if found necessary, to determine the most suited beneficiation and agglomeration process and equipment to give successful and economical smelting operation.

(b) *Neyveli Lignite*—Study availble data on briquetting and carbonising tests on Neyveli Lignite, evaluate the economics of the coke so produced keeping in view the suitability of this coke for smelting.

The Consulting Engineers, if necessary, shall also give their views in an interim note on the necessity to undertake a further mine-cut at Neyveli.

(c) Fluxes.

(d) Refractory raw materials.

4. METALLURGICAL PRODUCTION PROCESSES

Recommend the most suitable and economic metallurgical processes for the production of reductant iron, steel and finished products, based on physical and chemical characteristics of the raw materials available, local operating conditions and recent proved developments both in India and abroad. The recommendations shall be based on the evaluation of the following three ironmaking alternatives:

(a) Low Shaft Furnaces.

(b) Electric Smelting Furnaces with or without per-reduction Techniques.

(c) Lurgi Process.

In evaluating the above ironmaking alternatives, the Consulting Engineers shall study, as soon as made available, the results of smelting tests now being or to be conducted in East Germany, West Germany, USA, and Norway and determine whether adequate data exist for designing of large scale plant on this basis.

5. PLANT AND EQUIPMENT

On the basis of the recommended production processes and the plant production capacity, determine most suitable types and sizes of equipment (with alternative recommendations wherever necessary) for the production departments (viz. coke plant, ore beneficiation plant, iron-making plant, steel melting shop and rolling mills), utilities and auxiliary facilities. Equipment recommended shall be described in detail together with general specifications and other relevant particulars.

6. PLANT GENERAL LAYOUT

A general layout showing the disposition of production units with all auxiliary facilities such as water, power, fuel oil, steam, maintenance shops, laboratories and stores keeping in view the possibilities of future expansion.

7. PLANT UTILITIES & AUXILIARY SERVICES

The plant utilities such as water, power, fuel and steam, auxiliary facilities such as maintenance shops, laboratories, works transport and general amenities shall be described in detail.

8. CONSTRUCTION SCHEDULE

The Report shall contain a realistic and comprehensive time-schedule for the construction and erection of the Works in its entirety. This shall show separately for each department when the civil engineering works, structural erection, foundation work and plant installation shall commence and end.

9. CAPITAL COST ESTIMATES

An engineering estimate of the capital cost for the entire project department-wise, showing separately the cost of site preparation, civil and structural engineering, mechanical and electrical equipment, utilities and plant general facilities based on prevailing prices in local and foreign markets.

Preliminary specifications and estimates of quantities for civil engineering works, structural steelworks and other items of construction shall be included.

10. LABOUR FORCE ESTIMATE

Estimation of the labour and supervision force required to man each plant department including supervision and maintenance in sufficient detail.

11. PRODUCTION COST ESTIMATES

Estimates of works production costs for pig iron, steel and rolled products (semi-finished and finished products) based on estimated cost of raw materials and expected consumption of fuel, power, water, consumable materials, labour and other relevant items of expenditure.

12. ORGANISATION OF MANAGEMENT & TRAINING

An indication of the type of management structure and training programme for successful functioning of the various production units as an integrated plant.

IV. Time of completion of the Project Report.

1. The Consulting Engineers shall complete the Detailed Project Report as aforesaid within 12 (twelve) months from the date of this

Agreement provided that all the results of pilot plant tests now in progress and those that may be conducted in future and all the data and information to be furnished by Government as set out in Clause VI below are received by the Consulting Engineers within 7 (seven) months from the date of this Agreement provided further that the Consulting Engineers shall indicate within a period of 3 (three) months from the date of this Agreement what further tests are necessary to be carried out in their opinion. On completion of the Detailed Project Report, the Consulting Engineers shall submit 5 (five) copies thereof to the Government and shall within a further period of 8 to 10 weeks supply an additional 15 (fifteen) copies thereof.

2. In order that urgent work such as land acquisition and decision on cutting of new lignite seam at Neyveli be expedited interim reports as provided in Clause III on such work shall be submitted by the Consulting Engineers.

3. During the preparation of the Detailed Project Report the Consulting Engineers shall generally advise the Government on planning of necessary preliminary work at site such as traverse and contour surveys, subsoil investigation works, laying out of constructional facilities, that is, temporary water and power supply, drainage, construction sidings and roads, storage area for construction materials, structurals and equipment and requirements of construction equipment and tools.

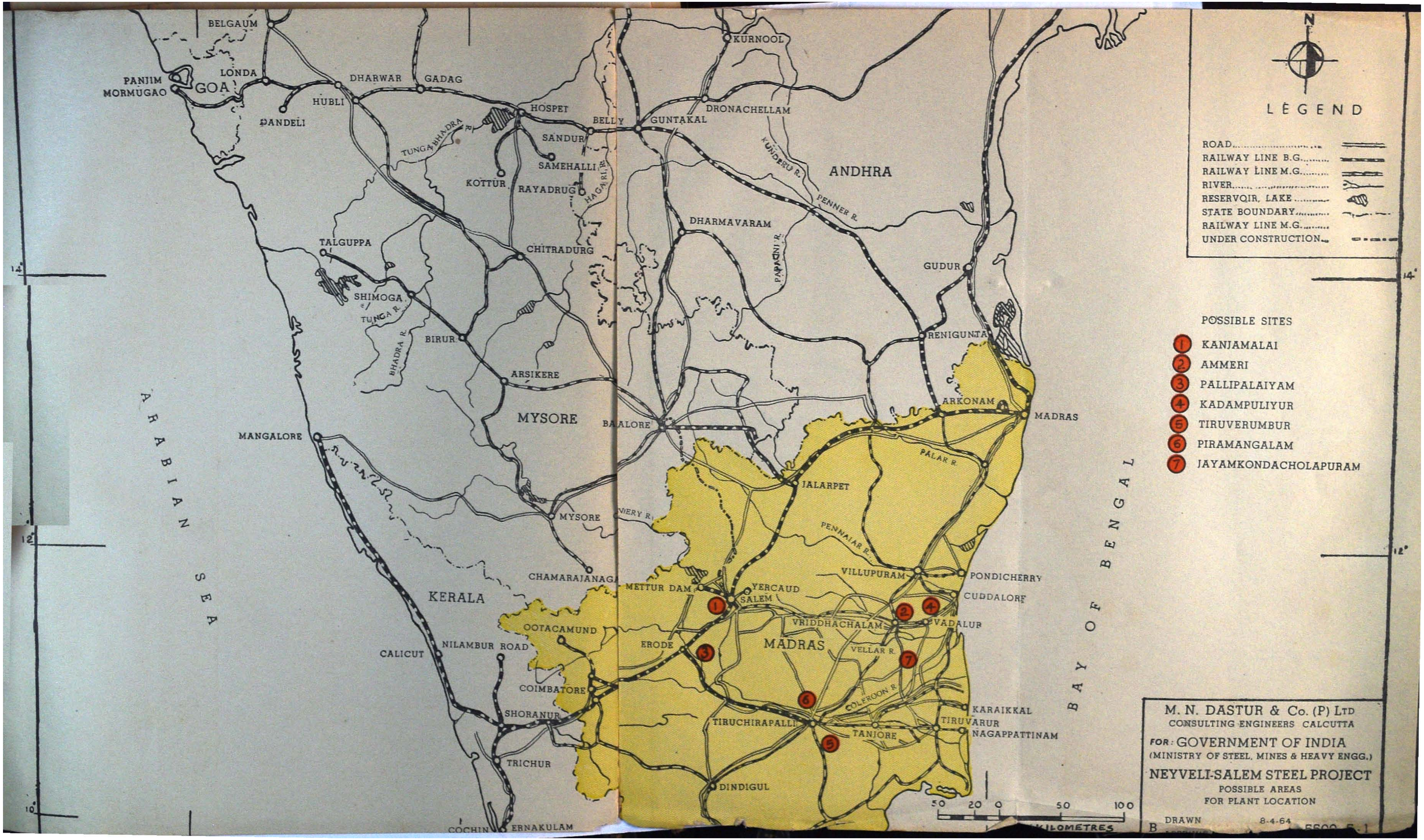
APPENDIX II

STEEL REQUIREMENTS IN NEYVELI-SALEM REGION IN 1970/71 AND 1975/76 AND SHORTFALLS IN STEEL PRODUCTION

(in thousand tons)

Products	*All India Shortfalls* 1970/71	*All India Shortfalls* 1975/76	*Steel Requirements in Neyveli-Salem Region* 1970/71	*Steel Requirements in Neyveli-Salem Region* 1975/76	*Expected Production of Re-rollers in Madras* 1970/71	*Expected Production of Re-rollers in Madras* 1975/76	*Shortfalls for Neyveli-Salem Project* 1970/71	*Shortfalls for Neyveli-Salem Project* 1975/76
Railway materials	706	1,148	104	139	—	—	104	139
Structurals								
Plain carbon steel	154	806	147	227	—	—	147	227
Low alloy high tensile steel	100	150	9	15	—	—	100	150
Sub-total: Structurals ...	254	956	156	242	—	—	247	377
Merchant sections								
Plain carbon steel	242	1,716	303	467	165	260	138	207
Free cutting steel	169	273	19	29	—	—	169	273
Low alloy constructional & spring steels ...	152	234	26	40	—	—	152	234
Sub-total: Merchant sections ...	563	2,223	348	536	165	260	459	714
Flat products								
HR sheet & strip	221	295	148	258	—	—	148	258
CR sheet & strip	409	404	137	235	—	—	137	235
Electrical sheet	50	188	14	24	—	—	14	24
Galvanised sheet	172	556	41	75	—	—	41	75
Tinplate	237	387	71	102	—	—	71	102
Light plate (up to 10 mm)	400	380	89	144	—	—	89	144
Heavy plate (above 10 mm)	+ 188	56	69	144	—	—	—	56
Sub-total: Flat products ...	1,301	2,266	569	982	—	—	500	894
Other products								
Blooms & billets for forging	+ 141	+ 10	84	48	—	—	—	—
Skelp and gothics	186	545	91	126	—	—	91	126
Alloy steels	107	270	67	97	—	—	107	270
Sub-total: Other products ...	152	805	192	271	—	—	198	395
Total Finished Steel ...	2,975	7,398	1,369	2,170	—	—	1,508	2,520
Total ingot steel (million tons) (at 1·33 times finished steel)	4·0	9·8	1·8	2·8	—	—	2·0	3·3

Note: + Indicates surplus


N
LEGEND
ROAD
RAILWAY LINE B.G.
RAILWAY LINE M.G.
RIVER
RESERVOIR, LAKE
STATE BOUNDARY
RAILWAY LINE M.G. UNDER CONSTRUCTION
POSSIBLE SITES
1 KANJAMALAI
2 AMMERI
3 PALLIPALAIYAM
4 KADAMPULIYUR
5 TIRUVERUMBUR
6 PIRAMANGALAM
7 JAYAMKONDACHOLAPURAM
ARABIAN SEA
BAY OF BENGAL
GOA
MYSORE
ANDHRA
KERALA
MADRAS
BELGAUM
PANJIM
MORMUGAO
LONDA
DANDELI
HUBLI
DHARWAR
GADAG
HOSPET
BELLY
SANDUR
SAMEHALLI
KOTTUR
RAYADRUG
TUNGABHADRA R.
HAGARI R.
KURNOOL
GUNTAKAL
DRONACHELLAM
KUNDERU R.
PENNER R.
DHARMAVARAM
PAPAGNI R.
GUDUR
TALGUPPA
SHIMOGA
TUNGA R.
BHADRA R.
CHITRADURG
BIRUR
ARSIKERE
RENIGUNTA
ARKONAM
MADRAS
PALAR R.
MANGALORE
JALARPET
MYSORE
PENNAIAR R.
CHAMARAJANAGAR
VILLUPURAM
PONDICHERRY
METTUR DAM
YERCAUD
SALEM
CUDDALORE
VRIDDHACHALAM
VADALUR
OOTACAMUND
ERODE
VELLAR R.
CALICUT
NILAMBUR ROAD
COIMBATORE
COLEROON R.
KARAIKKAL
SHORANUR
TIRUCHIRAPALLI
TANJORE
TIRUVARUR
NAGAPPATTINAM
TRICHUR
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COCHIN
ERNAKULAM
14°
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KILOMETRES
M. N. DASTUR & Co. (P) LTD
CONSULTING ENGINEERS CALCUTTA
FOR: GOVERNMENT OF INDIA
(MINISTRY OF STEEL, MINES & HEAVY ENGG.)
NEYVELI-SALEM STEEL PROJECT
POSSIBLE AREAS
FOR PLANT LOCATION
DRAWN 8-4-64
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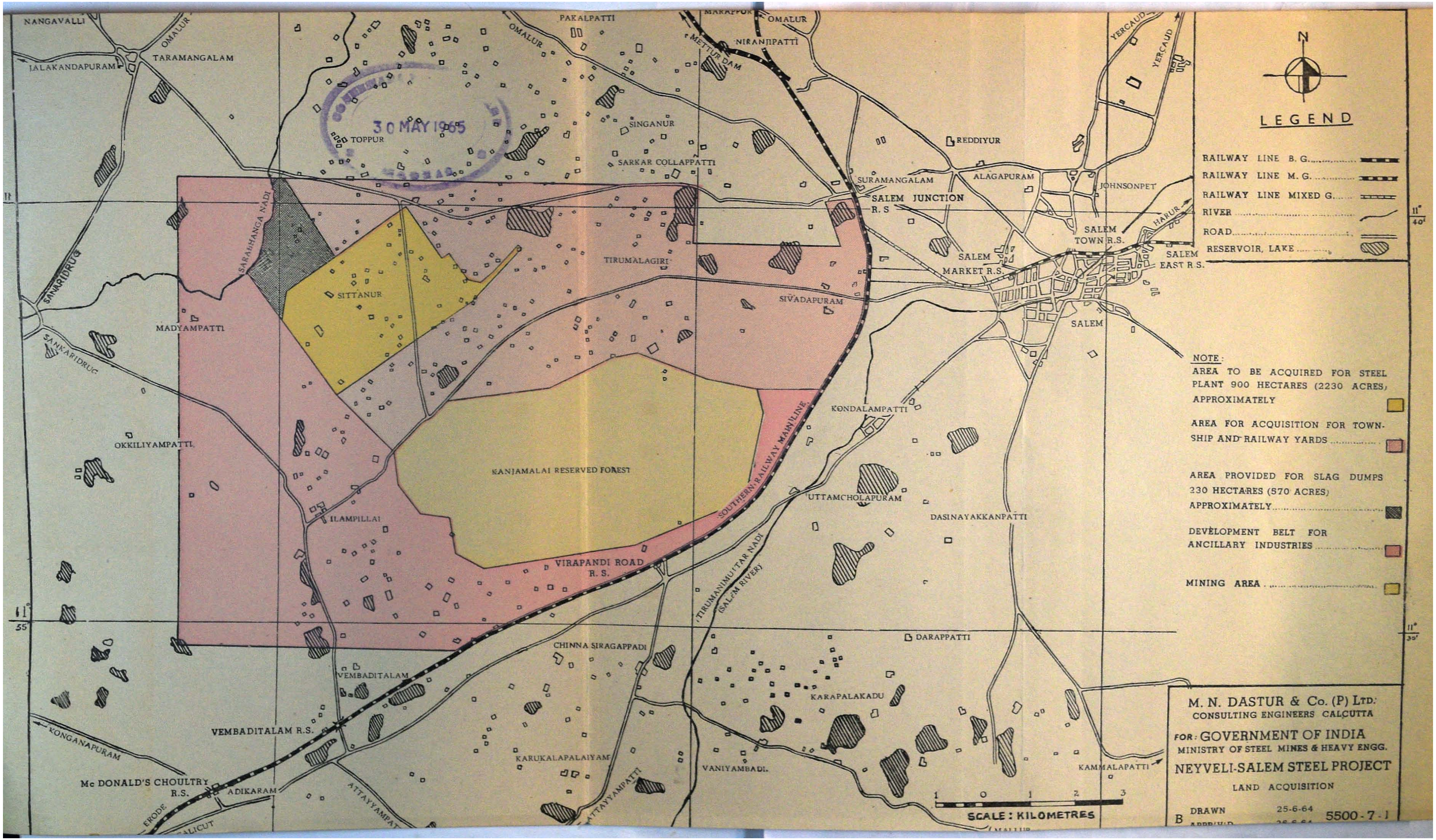
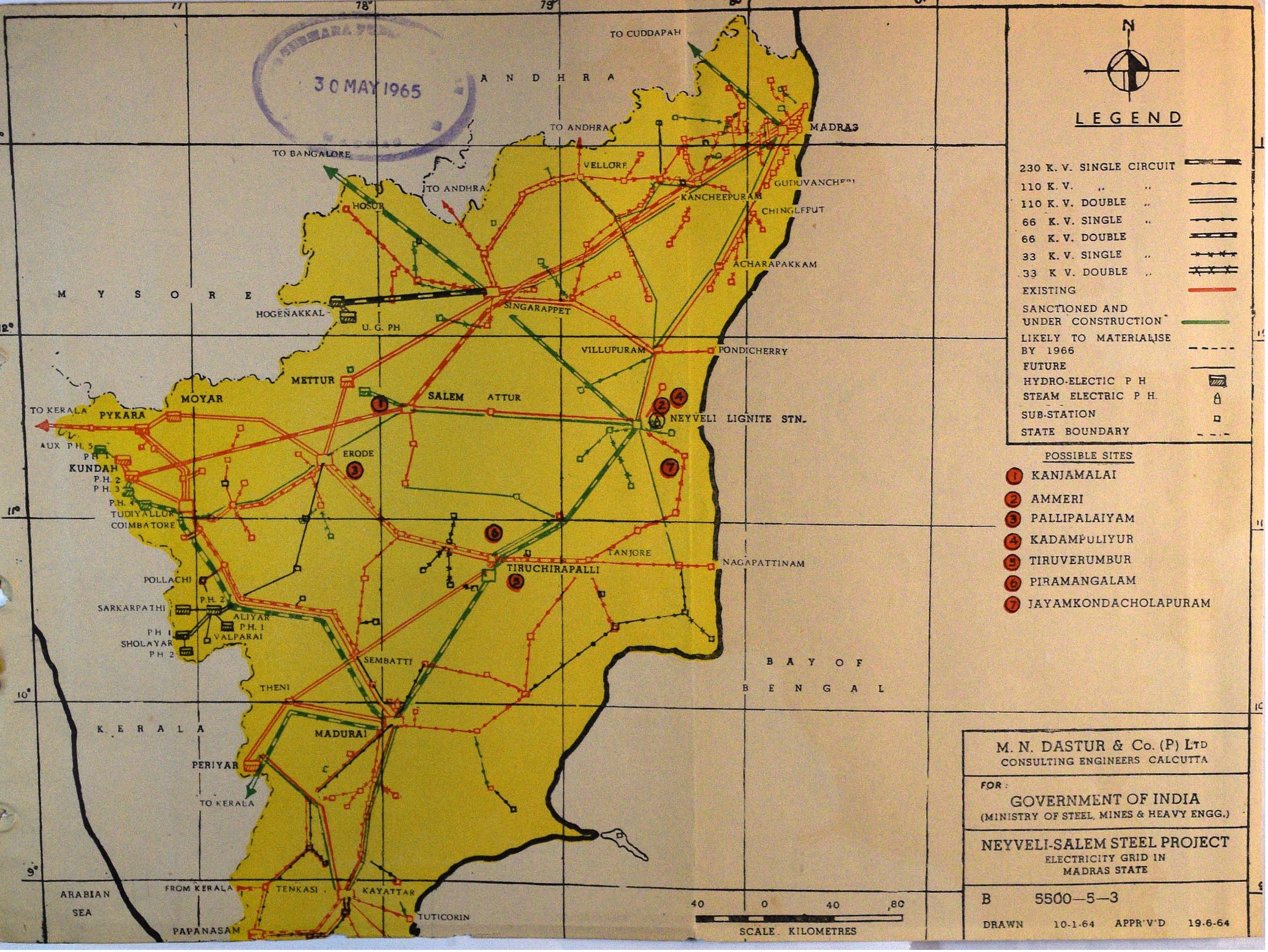

M. N. DASTUR & Co. (P) LTD.
CONSULTING ENGINEERS CALCUTTA
FOR: GOVERNMENT OF INDIA
MINISTRY OF STEEL MINES & HEAVY ENGG.
NEYVELI-SALEM STEEL PROJECT
LAND ACQUISITION
DRAWN 25-6-64
B
5500-7-1
LEGEND
RAILWAY LINE B. G.
RAILWAY LINE M. G.
RAILWAY LINE MIXED G.
RIVER
ROAD
RESERVOIR, LAKE
NOTE:
AREA TO BE ACQUIRED FOR STEEL PLANT 900 HECTARES (2230 ACRES) APPROXIMATELY
AREA FOR ACQUISITION FOR TOWNSHIP AND RAILWAY YARDS
AREA PROVIDED FOR SLAG DUMPS 230 HECTARES (570 ACRES) APPROXIMATELY
DEVELOPMENT BELT FOR ANCILLARY INDUSTRIES
MINING AREA
SCALE: KILOMETRES
1 0 1 2 3
N
30 MAY 1965
NANGAVALLI
OMALUR
TARAMANGALAM
JALAKANDAPURAM
PAKALPATTI
MARAPPOR
NIRANJIPATTI
METTUR DAM
YERCAUD
TOPPUR
SINGANUR
SARKAR COLLAPPATTI
REDDIYUR
SURAMANGALAM
ALAGAPURAM
JOHNSONPET
SALEM JUNCTION R. S
SALEM TOWN R.S.
HARUR
SALEM MARKET R.S.
SALEM EAST R.S.
SALEM
TIRUMALAGIRI
SIVADAPURAM
SARABHANGA NADI
SITTANUR
SANKARIDRUG
MADYAMPATTI
OKKILIYAMPATTI
KANJAMALAI RESERVED FOREST
SOUTHERN RAILWAY MAIN LINE
KONDALAMPATTI
UTTAMCHOLAPURAM
DASINAYAKKANPATTI
ILAMPILLAI
VIRAPANDI ROAD R. S.
TIRUMANIMUTTAR NADI (SALEM RIVER)
11° 55'
11° 40'
11° 39'
DARAPPATTI
CHINNA SIRAGAPPADI
VEMBADITALAM
KARAPALAKADU
VEMBADITALAM R.S.
KONGANAPURAM
KARUKALAPALAIYAM
VANIYAMBADI
KAMMALAPATTI
Mc DONALD'S CHOULTRY R.S.
ADIKARAM
ATTAYYAMPATTI
ERODE
CALICUT


30 MAY 1965
TO CUDDAPAH
A N D H R A
TO ANDHRA
MADRAS
TO BANGALORE
VELLORE
TO ANDHRA
HOSUR
GUDUVANCHERI
KANCHEEPURAM
CHINGLEPUT
ACHARAPAKKAM
M Y S O R E
HOGENAKKAL
SINGARAPPET
U. G. PH
VILLUPURAM
PONDICHERRY
METTUR
SALEM
ATTUR
TO KERALA
PYKARA
MOYAR
NEYVELI LIGNITE STN.
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KUNDAH
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P.H. 3
ERODE
P.H. 4
TUDIYALLUR
COIMBATORE
TANJORE
TIRUCHIRAPALLI
NAGAPATTINAM
POLLACHI
P.H. 2
SARKARPATHI
ALIYAR
P.H. 1
PH 1
SHOLAYAR
PH 2
VALPARAI
SEMBATTI
THENI
B A Y O F
B E N G A L
K E R A L A
MADURAI
PERIYAR
TO KERALA
ARABIAN
SEA
FROM KERALA
TENKASI
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TUTICORIN
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81°
13°
12°
11°
10°
9°
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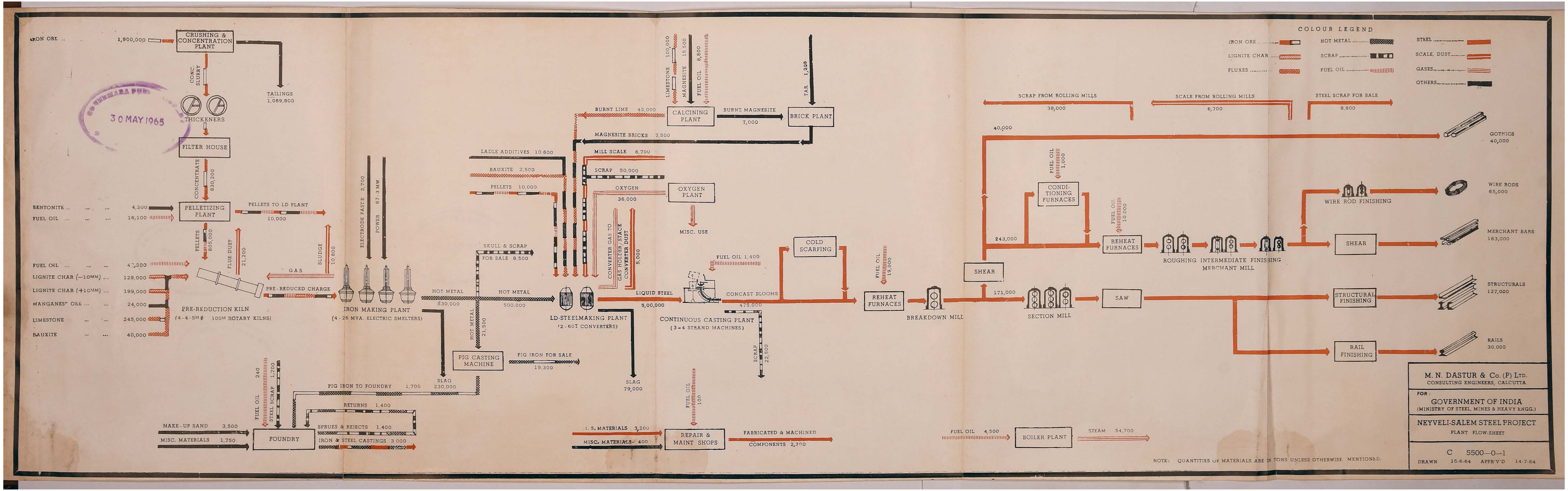
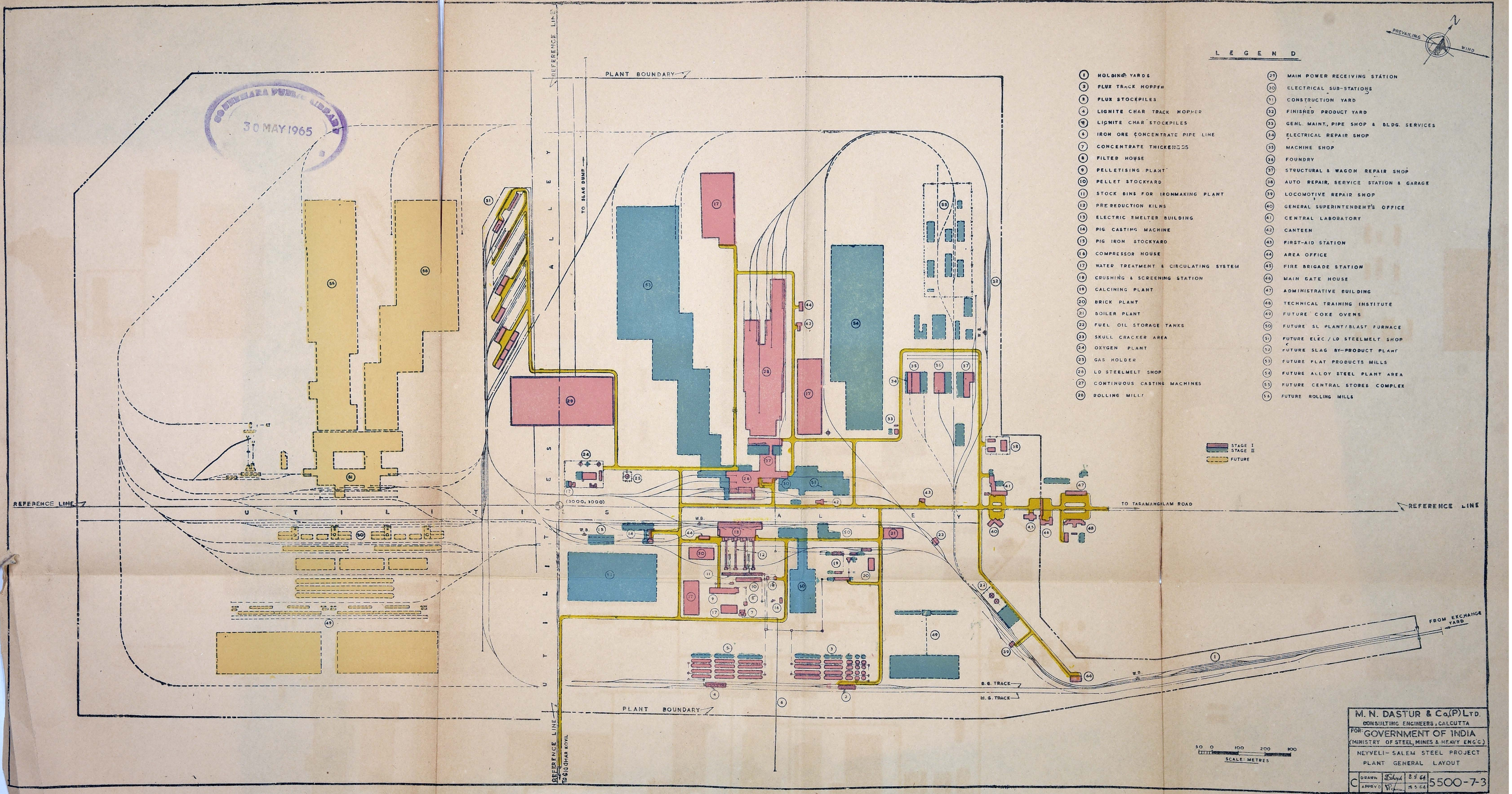
40
80
SCALE KILOMETRES
N
LEGEND
230 K. V. SINGLE CIRCUIT
110 K. V.
110 K. V. DOUBLE
66 K. V. SINGLE
66 K. V. DOUBLE
33 K. V. SINGLE
33 K V. DOUBLE
EXISTING
SANCTIONED AND UNDER CONSTRUCTION
LIKELY TO MATERIALISE BY 1966
FUTURE
HYDRO-ELECTRIC P H
STEAM ELECTRIC P H.
SUB-STATION
STATE BOUNDARY
POSSIBLE SITES
1 KANJAMALAI
2 AMMERI
3 PALLIPALAIYAM
4 KADAMPULIYUR
5 TIRUVERUMBUR
6 PIRAMANGALAM
7 JAYAMKONDACHOLAPURAM
M. N. DASTUR & Co. (P) LTD
CONSULTING ENGINEERS CALCUTTA
FOR:
GOVERNMENT OF INDIA
(MINISTRY OF STEEL, MINES & HEAVY ENGG.)
NEYVELI-SALEM STEEL PROJECT
ELECTRICITY GRID IN
MADRAS STATE
B 5500—5—3
DRAWN 10-1-64 APPR'V'D 19-6-64



COLOUR LEGEND
IRON ORE
LIGNITE CHAR
FLUXES
HOT METAL
SCRAP
FUEL OIL
STEEL
SCALE, DUST
GASES
OTHERS
IRON ORE 1,900,000
CRUSHING & CONCENTRATION PLANT
TAILINGS 1,069,800
CONC. SLURRY
THICKENERS
FILTER HOUSE
CONCENTRATE 830,200
BENTONITE 4,200
FUEL OIL 16,100
PELLETIZING PLANT
PELLETS TO LD PLANT 10,000
PELLETS 805,000
FLUE DUST 21,200
SLUDGE 10,800
GAS
FUEL OIL 47,200
LIGNITE CHAR (–10MM) 129,000
LIGNITE CHAR (+10MM) 199,000
MANGANESE ORE 24,000
LIMESTONE 245,000
BAUXITE 40,000
PRE-REDUCED CHARGE
PRE-REDUCTION KILN
(4 - 4·5M ϕ 100M ROTARY KILNS)
ELECTRODE PASTE 2,700
POWER 67·3 MW
IRON MAKING PLANT
(4 - 26 MVA. ELECTRIC SMELTERS)
HOT METAL 530,000
HOT METAL 500,000
HOT METAL 21,500
SKULL & SCRAP FOR SALE 8,500
PIG CASTING MACHINE
PIG IRON FOR SALE 19,300
SLAG 230,000
PIG IRON TO FOUNDRY 1,700
FUEL OIL 240
STEEL SCRAP 1,700
RETURNS 1,400
SPRUES & REJECTS 1,400
IRON & STEEL CASTINGS 3,000
MAKE-UP SAND 3,500
MISC. MATERIALS 1,750
FOUNDRY
LADLE ADDITIVES 10,600
BAUXITE 2,500
PELLETS 10,000
BURNT LIME 45,000
MAGNESITE BRICKS 7,500
MILL SCALE 6,700
SCRAP 50,000
OXYGEN 36,000
LIMESTONE 100,000
MAGNESITE 15,500
FUEL OIL 8,800
CALCINING PLANT
BURNT MAGNESITE 7,000
TAR 1,200
BRICK PLANT
OXYGEN PLANT
MISC. USE
CONVERTER GAS TO GAS HOLDER/STACK
CONVERTER DUST 5,000
LD-STEELMAKING PLANT
(2 - 60T CONVERTERS)
SLAG 79,000
LIQUID STEEL 5,00,000
FUEL OIL 1,400
CONTINUOUS CASTING PLANT
(3 - 4 STRAND MACHINES)
CONCAST BLOOMS 475,000
SCRAP 22,500
COLD SCARFING
FUEL OIL 100
I. S. MATERIALS 3,200
MISC. MATERIALS 400
REPAIR & MAINT SHOPS
FABRICATED & MACHINED COMPONENTS 2,300
FUEL OIL 19,000
REHEAT FURNACES
BREAKDOWN MILL
SHEAR
SCRAP FROM ROLLING MILLS 38,000
SCALE FROM ROLLING MILLS 6,700
STEEL SCRAP FOR SALE 8,800
40,000
FUEL OIL 1,000
CONDITIONING FURNACES
FUEL OIL 10,000
243,000
REHEAT FURNACES
ROUGHING INTERMEDIATE FINISHING
MERCHANT MILL
WIRE ROD FINISHING
SHEAR
171,000
SECTION MILL
SAW
STRUCTURAL FINISHING
RAIL FINISHING
GOTHICS 40,000
WIRE RODS 65,000
MERCHANT BARS 163,000
STRUCTURALS 127,000
RAILS 30,000
FUEL OIL 4,500
BOILER PLANT
STEAM 54,700
NOTE: QUANTITIES OF MATERIALS ARE IN TONS UNLESS OTHERWISE MENTIONED.
M. N. DASTUR & Co. (P) LTD.
CONSULTING ENGINEERS, CALCUTTA
FOR
GOVERNMENT OF INDIA
(MINISTRY OF STEEL, MINES & HEAVY ENGG.)
NEYVELI-SALEM STEEL PROJECT
PLANT FLOW-SHEET
C 5500—0—1
DRAWN 15-6-64 APPR'V'D 14-7-64

30 MAY 1965



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